Iron and Steel Engineer

Established 1907 as Proceedings of A. I. & S. E. E.

J. F. KELLY, *Editor*

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Entered as second-class matter January 25th, 1924, at Pittsburgh, Pa., under the Act of March 3rd, 1879.
Subscription Price $5.00 per Year. Single Copy 50c.

Mr. F. O. Schnure, Electrical Superintendent, Bethlehem Steel Co., Sparrows Point, Md., President of the Association of Iron and Steel Electrical Engineers for the year 1930-1931.

EDITORIAL

Everybody's Problem Lubrication

Like an old foot ball, lubrication for the past thirty years has been kicked from pillar to post, nobody claimed it, yet everybody used it.

It seemed that its common usage created a contempt by its familiarity. Oil shanties, located at some distant outpost in the steel plant, housed an indiscriminate mixture of oils, and greases. The oil man or custodian dished out quantities of oils and greases often regardless as to the uses intended, the prevailing opinion being that so long as it was oil or grease, it would perform the task.

After the lubricant had run its course, it lay about in the plant in unsightly piles, in pits, around engines, under roll tables, mixed with scale, waste, and every conceivable nondescript matter about the plant.

The author remembers in the early days in one particular steel plant, which was a Sheet and Tin mill, when thirty hot mill catchers had as part of their responsibilities the greasing of the hot necks with a material no ax could penetrate, it even resisted red hot metal application with the result that there was little, if any, lubrication, and what there was consisted of a blinding, choking smoke which caused almost unbearable working conditions, loss of production, broken rolls and a high maintenance.

About the only piece of apparatus in the entire plant which received any attention, so far as lubrication was concerned, was the steam engine. Barrels of oil, tubs of grease, stood close by, and were applied liberally.

Finally, some of the enterprising mechanics in the industry awakened to the fact that, if lubrication was properly used and applied, many of the conditions prevailing at that time could be eliminated. However, it remained for the commercial engineer on the outside of the plant to realize the enormous possibilities and savings, which could be effected by the use, of first, specific lubricants for specific applications; and second, lubrication devices, appliances, and systems, many of them automatic, which practically eliminated the human element.

The results so far obtained have proven:

First—That the consumption of lubricants may be reduced as much as 50 percent or more.

Second—Reduction in maintenance and upkeep costs as high as several hundred percent.

Third—A reduction in power load, in some cases as high as 25 percent.

Fourth—A reduction in delays. This is one of the greatest gains particularly in a rolling mill, from the finished bar clear back to the heating furnace.

Fifth—Proper lubrication produces a better section in rolling mills. As is readily appreciated, any change in a roll neck bearing is immediately found in the finished bar, even a sloppy pinion bearing causes a wave in the finished bar.

Sixth—Reduces man hours. By use of proper lubricants and proper appliances, less men are required to apply lubricants.

Seventh—Makes for cleanliness and health; a clean mill and a healthy place is a cheerful place to work. Cleanliness lends an inspiration to all men.

Eighth—Reduces accidents. By use of proper applicances, the bearings may be lubricated from a remote point.

Ninth—Not so much time required to line up the mills.

Tenth—A new system of accounting, in which is taken into consideration that lubrication should be charged with all bearing changes, delays in lining up the mills, loss of production through delays caused by faulty bearing performance.

Proper lubrication is today one of the problems that confronts the Iron and Steel Industry. It is the fertile and virgin field; in indirect savings, the figures will total millions of dollars. There is plenty of work to be done.

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Report on Questionnaire Covering Organization, Maintenance, and Operation of an Electrical Department in a Modern Steel Mill

By J. J. Booth*

At the 1929 convention of the Association of Iron and Steel Electrical Engineers in Pittsburgh, June 17-21, 1929, we presented a questionnaire, covering the organization, maintenance and operation of an Electrical Department in a Modern Steel Mill, with the request that as many of our active members as possible take this questionnaire and fill it out in detail, mailing it to the Chairman of the Shop Practice Committee. This has been done by several of our active members and below we wish to present the general results of this questionnaire, representing some ten steel plants, ranging in size from 1,000 to 13,000 employees.

From the chart on Page 408-A we believe that any Electrical Engineer, wishing to set up or establish an Electrical Organization in a Steel Plant, as covered by these reports, will find this data a helpful guide.

In order that we may bring out more of the particulars of the actual organization and maintenance of the Electrical Department, in a steel mill, we propose in the following pages, to outline what we term a representative 100% organization. In so doing, we have tried to cover all points in as much detail as practicable in a paper of this kind, using the general outline of the questionnaire as our guide.

1. ORGANIZATION

The Electrical Organization of any Steel Mill is as strong as its Electrical Superintendent. He should have only one superior from whom he takes orders and to whom he is responsible for the efficient operation of his organization and equipment. Since the Electrical Superintendent is the one who loses sleep when his equipment fails to operate properly, he should have full power to prepare all specifications for new equipment to be purchased and be the judge as to what suppliers can meet such specifications. With this as a foundation, we have prepared the organization tree, shown in Figure (1), so that the general arrangement of the engineering, clerical, operation, testing, and maintenance departments form an ideal Electrical Organization, with the Electrical Superintendent as its head, reporting direct to the General Superintendent of the Plant and his assistant.

2. SIZE OF PLANT

The organization as outlined above, is suitable for a complete steel mill, employing approximately 7500 men. This plant should have approximately 278 by-product coke ovens, four blast furnaces, two open hearths, one having 12 furnaces and one 15 furnaces, and complete rolling mills. The finished products are pig iron, billets, sheets, bars, rounds, plates, merchant bars, galvanized sheets, structural pieces, rails, splice bars, tie plates, bolts, rivets and spikes.

A. Clerical Department

1. Preparing of Orders

The writing of orders for repair parts originate with the foreman of the department requesting the parts. His requisition carries the necessary data for the Purchasing Department to order these parts from the manufacturer of the original equipment, these orders being sent by the Foreman to the Electrical Superintendent's Office for approval and rewriting.

Orders for new equipment originate in the office of the Electrical Superintendent, who in conjunction with the Chief Engineer, prepares the design and layout of all new installations and replacement of old equipment, the Electrical Superintendent being responsible for all specifications and designs of Electrical Equipment.

2. Distribution of Time

The distribution of time is divided into two methods. The Inspection and Construction Departments in the field use a time slip which provides space for seven coupons, to show the work performed, time in hours and minutes, order number, account number and wage per coupon. See Figure (2). Each coupon is used to show the time required and work performed for a specific department. If a man's time for a day is divided between three departments, he fills out three coupons. The next day these are returned to the Department Superintendent for checking, signed and returned to the Time Department. In this manner the department involved can question any work charged against them while it is fresh in the minds of those affected, and at the same time this affords the Department Superintendent the privilege of knowing exactly what is charged to his department from the standpoint of maintenance cost. The Electric Repair Shop has a special time slip which will be explained under the discussion of the Electric Repair Shop.

Each morning the Electrical Superintendent has placed on his desk, a summary time slip, showing the labor distribution for the previous day. See Figure (3). Each foreman receives a daily report from each motor inspector at 8:00 A. M. covering the general maintenance and repair work performed by him on the previous day. See Figure (4). From this he prepares a summary inspection report and forwards it to the Electrical Superintendent before 11:00 A. M. each day, so that the latter may have

* Chairman, Shop Practice Committee; Electrical Superintendent, National Tube Company, Gary, Indiana.

† Presented at 26th Annual A. I. & S. E. E. Convention, Buffalo, N. Y., June, 1930.

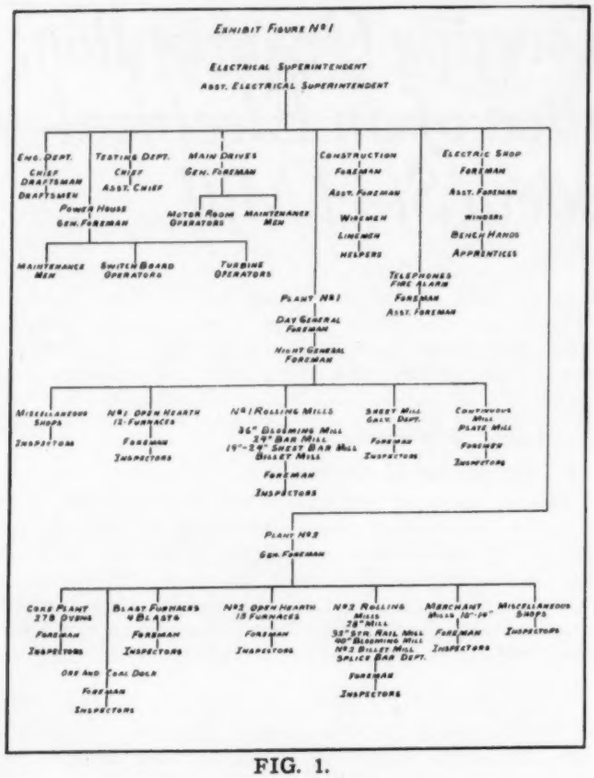


FIG. 1.

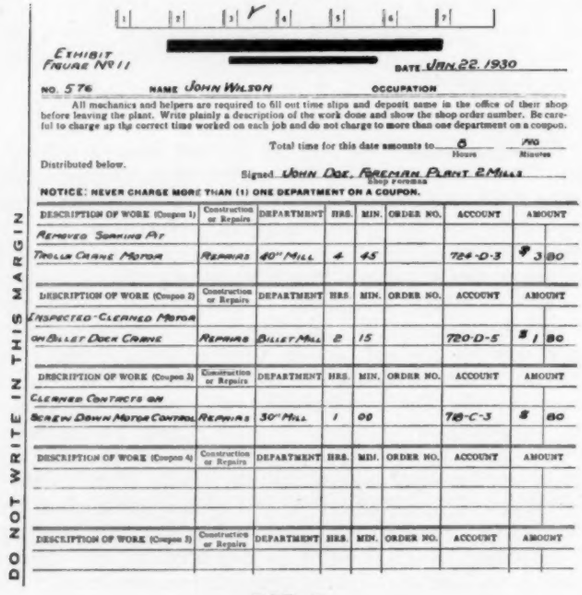


EXHIBIT FIGURE No II
DATE JAN. 22. 1930
NO. 576 NAME JOHN WILSON OCCUPATION
All mechanics and helpers are required to fill out time slips and deposit same in the office of their shop before leaving the plant. Write plainly a description of the work done and show the shop order number. Be careful to charge up the correct time worked on each job and do not charge to more than one department on a coupon.
Total time for this date amounts to 8 Hours Min
Distributed below.
Signed JOHN DOE, FOREMAN PLANT 2 MILLS
Shop Foreman
NOTICE: NEVER CHARGE MORE THAN (1) ONE DEPARTMENT ON A COUPON.
DESCRIPTION OF WORK (Coupon 1) | Construction or Repairs | DEPARTMENT | HRS. | MIN. | ORDER NO. | ACCOUNT | AMOUNT
Removed Sorting Pit
Trolley Crane Motor | Repairs | 40" Mill | 4 | 45 | | 724-D-3 | $3 80
DESCRIPTION OF WORK (Coupon 2) | Construction or Repairs | DEPARTMENT | HRS. | MIN. | ORDER NO. | ACCOUNT | AMOUNT
Inspected-Cleaned Motor
on Billet Dock Crane | Repairs | Billet Mill | 2 | 15 | | 720-D-5 | $1 80
DESCRIPTION OF WORK (Coupon 3) | Construction or Repairs | DEPARTMENT | HRS. | MIN. | ORDER NO. | ACCOUNT | AMOUNT
Cleaned Contacts on
Screw Down Motor Control | Repairs | 30" Mill | 1 | 00 | | 728-C-3 | $ 80
DESCRIPTION OF WORK (Coupon 4) | Construction or Repairs | DEPARTMENT | HRS. | MIN. | ORDER NO. | ACCOUNT | AMOUNT
DESCRIPTION OF WORK (Coupon 5) | Construction or Repairs | DEPARTMENT | HRS. | MIN. | ORDER NO. | ACCOUNT | AMOUNT
DO NOT WRITE IN THIS MARGIN

FIG. 2.

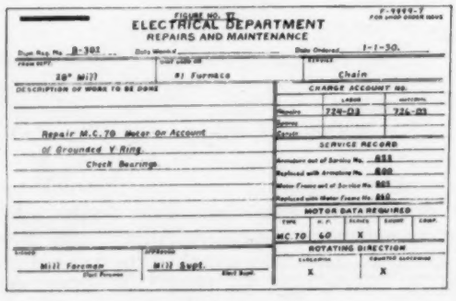


FIG. 6.

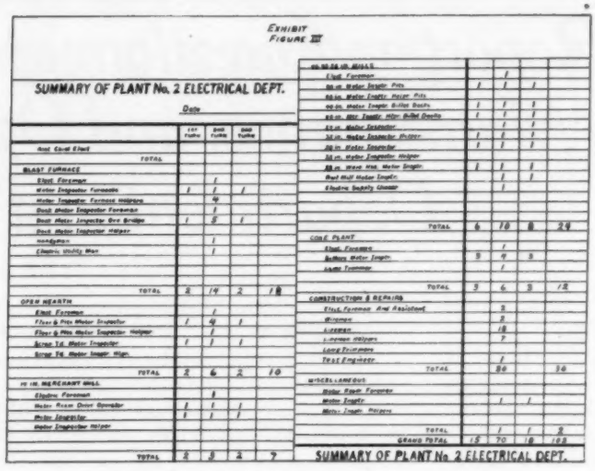


FIG. 3.

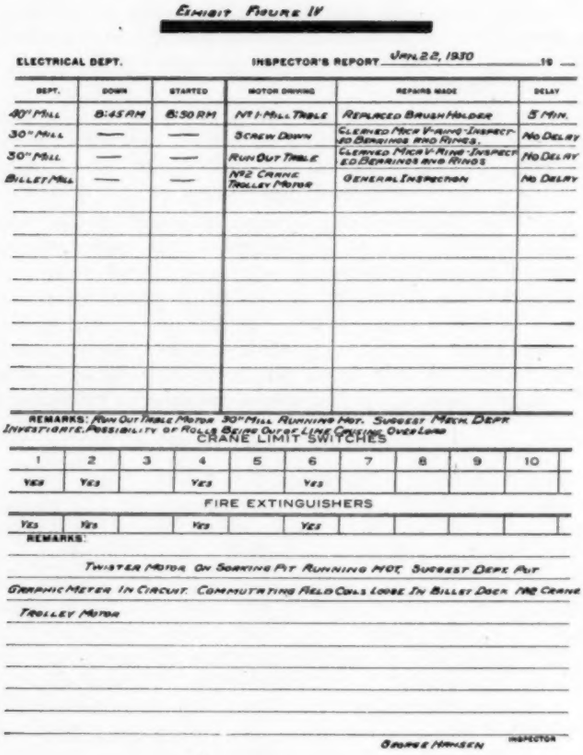


EXHIBIT FIGURE IV
ELECTRICAL DEPT.
INSPECTOR'S REPORT JAN. 22, 1930
DEPT. | DOWN | STARTED | MOTOR DRIVING | REPAIRS MADE | DELAY
40" Mill | 8:45 AM | 8:50 AM | No 1 Mill Table | Replaced Brush Holder | 5 Min.
30" Mill | — | — | Screw Down | Cleaned Mica V-Rings-Inspect. All Bearings and Rings. | No Delay
30" Mill | — | — | Run Out Table | Cleaned Mica V-Rings-Inspect. All Bearings and Rings. | No Delay
Billet Mill | — | — | No 2 Crane Trolley Motor | General Inspection | No Delay
REMARKS: Run Out Table Motor 30" Mill Running Hot. Suggest Mech. Dept. Investigate. Possibility of Rolls Being Out of Line Causing Overload
CRANE LIMIT SWITCHES
1 2 3 4 5 6 7 8 9 10
Yes Yes Yes Yes
FIRE EXTINGUISHERS
Yes Yes Yes Yes
REMARKS:
Twister Motor On Soaking Pit Running Hot. Suggest Dept. Put
Graphic Meter In Circuit. Commutating Field Coils Loose In Billet Dock No 2 Crane
Trolley Motor
George Hansen INSPECTOR

FIG. 4.

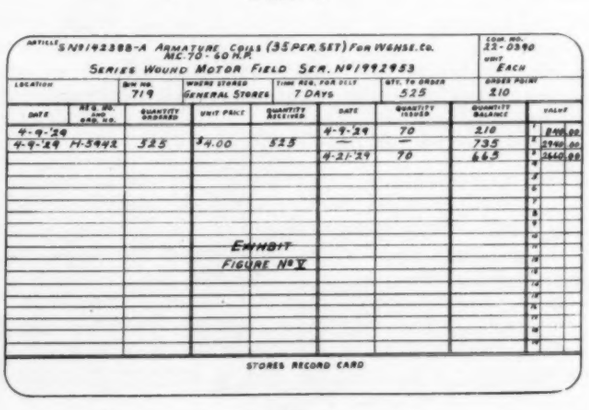

ARTICLE S No 1942388-A Armature Coils (35 per set) For W&HSE. Co. MC 70 - 60 H.P.
Series Wound Motor Field Ser. No 1992953
CODE NO. 22-0390
UNIT Each
LOCATION
BIN NO. 719
WHERE STORED General Stores
TIME REQ. FOR DELY 7 Days
QTY. TO ORDER 525
ORDER POINT 210
DATE | REC'D ON ORD. NO. | QUANTITY ORDERED | UNIT PRICE | QUANTITY RECEIVED | DATE | QUANTITY ISSUED | QUANTITY BALANCE | VALUE
4-9-'29 | | | | | 4-9-'29 | 70 | 210 | 1 $945.00
4-9-'29 H-5442 | | 525 | $4.00 | 525 | — | 735 | 2 2940.00
4-21-'29 | | | | | 4-21-'29 | 70 | 665 | 3 2660.00
EXHIBIT FIGURE No V
STORES RECORD CARD

FIG. 5.

an opportunity of knowing what has transpired in the last 24 hours, before going to the daily superintendent's meeting at 1:00 P. M.

B. Stores

The Electrical Stores should come under the general supervision of the Chief Store Keeper, who has under his employ a competent man familiar with the details of ordering Electrical Equipment. We believe this method to be preferable to that of having the Stores Department directly under the Electrical Superintendent. In some instances, which in our opinion are very rare, the Electrical Superintendent might be justified in carrying a Sub-Storeroom under his supervision, for outlying departments. Since the chief duty of the Store Keeper is to keep on hand at all times, necessary supplies required to operate and maintain a plant, he is in a better position to handle orders, make claims and settle adjustments than the Electrical Department. The Electrical Superintendent must approve all requisitions for materials to be carried in the stores stock, as well as requisitions for material not carried in stock. In order that the Stores Inventory may be kept to a minimum at all times, we have established a maximum and minimum point method of ordering commodities. This is set at 30 days for fast moving items and 90 days for slow moving items. The maximum and minimum is also determined by the delivery which can be met by the manufacturer.

Figure (5) shows a sample stores record card, having ample space at the top for a complete description of the part to be ordered, quantity to be ordered, commodity number, unit, bin number, date, order number, quantity received, date and quantity issued, balance on hand and its value. The ordering point is a minimum point to which the store can drop before ordering, which on this card is set at 210. The 525, quantity to be ordered, plus the 210, ordering point, gives the maximum on hand at any time of 735, for this particular item.

A close and efficient check is kept on stores at all times and an inventory taken every 30 days. This permits a minimum which is consistent with efficient handling of the commodity involved and permits scrapping or disposing of excess stock which may become obsolete or damaged in stock. This scrapping program is more efficient and easily handled because it is easier to charge off small amounts each month than large amounts at the end of the year. Also it provides 11 more opportunities each year for the Electrical Superintendent to view slow moving electrical items, thereby preventing re-ordering and in the end, decreasing inactive stock which may have to be scrapped at a later date.

Spare motors and armatures are necessary in any type of plant, regardless of size. These should be kept in the Electric Repair Shop under the direct supervision of the foreman of the shop, in order that he may be in a position to expedite delivery of motors of respective capacities to any place in the mill, where same may be required. Relative to spare armatures, the majority of armatures should be kept in the Electric Repair Shop in order that the pinions, brake wheels, pulleys, etc., may be properly installed before being sent to the mill. However, it is imperative that a specified number of spares be kept in the immediate vicinity where they are to be used. This not only expedites changing the electrical equipment in case of breakdown, but decreases the amount of mill delay and loss of production. In most instances where these spares are kept in the mill, in view of the fact that they are more or less special, pinions and brake wheels can be kept mounted on the shaft, ready for service. In carrying spare armatures both in the Electric Repair Shop and in the mill, it is well that in so far as practicable the bearings should be mounted on shafts, thus making the unit complete and easily installed. The Electrical Superintendent should see that accurate record of all spare motors and armatures, together with their locations, be kept in the hands of every foreman.

C. Engineering Department

The Electrical Department organization should include, under the supervision of the Electrical Superintendent, a small engineering department, consisting of one or more electrical draftsmen, preferably college trained. This department is to handle general layout work and compile all necessary records and engineering data which may be of future value to the Electrical Superintendent. On all new and replacement work the Electrical Superintendent will co-operate with the Chief Engineer.

D. Electric Repair Shop

In order to better study the Electric Repair Shop, its forms and methods of compiling costs, we will follow a complete motor through the shop on a cost incentive system, sent in for repairs. When the motor is taken out of the mill by the Mill Electrical Foreman or one of his representatives, the motor is inspected to determine the extent of repairs and what he thinks will be needed to put it in first class condition. He checks the serial number on the motor frame or end of shaft and prepares same for shipment to Electric Repair Shop. The foreman then prepares a foreman's maintenance or repair requisition, which gives a complete description of the work to be performed in accordance with his judgment, the charge account for the labor and material, the service record data, such as motor number and the date taken from service and the number of motor put in its place, the complete motor rating and the direction of rotation. This form is filled out in triplicate, (white, pink and blue copies) and signed by the Mill Electrical Foreman. Figure (6). The white copy is mailed to the Mill Superintendent for his noting and returned to the Mill Electrical Foreman who forwards it to the Electric Repair Shop. The pink copy is mailed to the Electrical Superintendent for his O.K. and comments, after which it is returned to the Mill Electrical Foreman. The third or blue copy is retained by the issuer, in his mill office as a record of work to be performed.

The three section blue shipping tag shown in Figure (7) is then prepared, the section with a wire in the perforated hole is attached to the motor, and sent with the motor to the Electric Repair Shop. The middle section is torn off and mailed to the foreman of the Electric Repair Shop, thus informing him that a motor has been sent in for repairs. The end section is retained by the Mill Electrical Foreman showing he has shipped the armature to the Repair Shop. When the middle section is received at the Electric Repair Shop, the receiving clerk, who

EXHIBIT FIGURE Nº VII

DEPT. SHIPPING TAG TO SHOPS

TO DEP'T. ELECTRIC REPAIR SHOP

FROM DEP'T. 28" MILL

SHOP ORDER NO. _____ BLUE PRINT NO. 1-M.C.70 MOTOR ARMATURE & BGS.

QNTY. WANTED _____ QNTY. SHIPPED TO SHOP ONE

DATE WANTED _____ DATE SHIPPED TO SHOP _____

HOW SHIPPED TO SHOP TRUCK

SHIPPED BY FOREMAN

This Tag—To Be Sent With Material

TO DEP'T. ELECTRIC REPAIR SHOP

FROM DEP'T. 28" MILL

SHOP ORDER NO. _____ BLUE PRINT NO. 1-M.C.70 MOTOR ARMATURE & BGS.

QNTY. WANTED _____ QNTY. SHIPPED TO SHOP ONE

DATE WANTED _____ DATE SHIPPED TO SHOP _____

HOW SHIPPED TO SHOP TRUCK

SHIPPED BY FOREMAN

This Tag—To Be Sent To Shop By Mail

TO DEP'T. ELECTRIC REPAIR SHOP

FROM DEP'T. 28" MILL

SHOP ORDER NO. _____ BLUE PRINT NO. 1-M.C.70 MOTOR ARMATURE & BGS.

QNTY. WANTED _____ QNTY. SHIPPED TO SHOP ONE

DATE WANTED _____ DATE SHIPPED TO SHOP _____

HOW SHIPPED TO SHOP TRUCK

SHIPPED BY FOREMAN

This Tag—To Be Kept By Dept. Sending Material

FIG. 7.

FIGURE VIII SHOP ORDER NO. F-9999-T

Dept. 28" Mill Motor 805 Arm. 853 Type 70 MC ser.

Manufacture Westinghouse Style No. L58295

Serial No. 1992953 Wound Series Brushes West. WL-30

Speed 475 R.P.M. Fitting

General condition of machine when coming to shop Front V-ring grounded. Armature roasted out and bands off. Grounded main field coil and commutating field coil needs reinsulating. Babbitt broken in one bearing. Repair jack shaft bearing.

Repairs Made As listed above

Check for bearings 1 bearing had babbitt broken. Jack-shaft loose in motor frame.

Check for end play Excessive

Fields tested for polarity O. K.

Fields tested for short No shorted turns

Fields tested for ground Main top series grounded

Fields tested for neutral

Brushes sanded in

W.F.C. Signed Jack Williams - Repair Shop Inspector

FIG. 8.

EXHIBIT FIGURE Nº IX

SHOP WORK ORDER

No. F-9999-T

DEPT. NO. 15 DATE JAN. 22, 1930

FOR 28" Mill

NAME OF UNIT Nº 1 FURNACE CHAIN

CHARGE DEPT. 28" Mill — COST: X — REPAIRS — SPARES

BLUE PRINT NO. — CHARGE ACCOUNT NO. LABOR: L-724-D-3 MATERIAL: M-726-D-3

DATE WANTED FEB. 18, 1930

DESCRIPTION OF WORK TO BE DONE

M.C. 70 MOTOR RETURNED TO THE REPAIR SHOP FOR REPAIRS ON ACCOUNT OF GROUNDED V-RING

REPAIR COMMUTATOR
REINSULATE ALL FIELD COILS
REPAIR BRUSH-HOLDER
REBABBITT ARMATURE AND JACK SHAFT BEARINGS
WELD AND REDRILL DOWEL HOLES IN JACK SHAFT BRACKET

ARMATURE OUT OF SERVICE, Nº 853 - REPLACED BY ARMATURE Nº 800
MOTOR OUT OF SERVICE Nº 805 - REPLACED BY MOTOR Nº 860

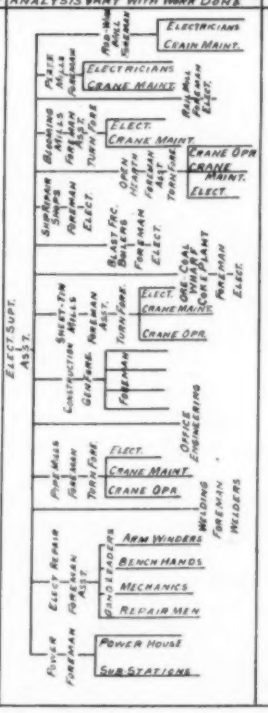
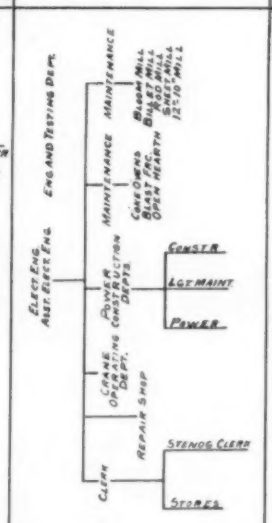
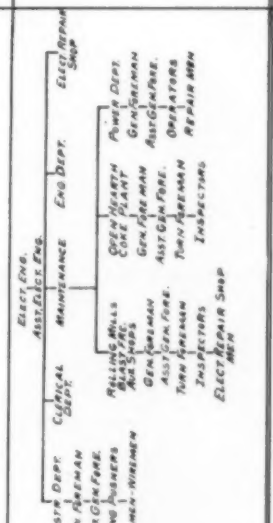
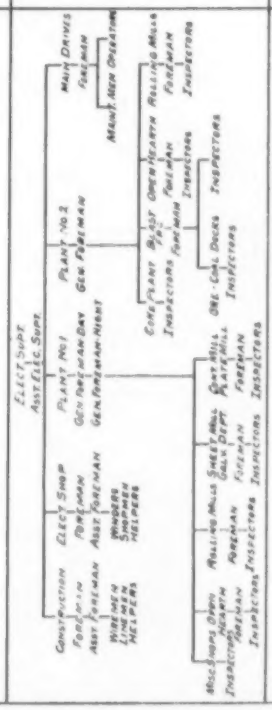
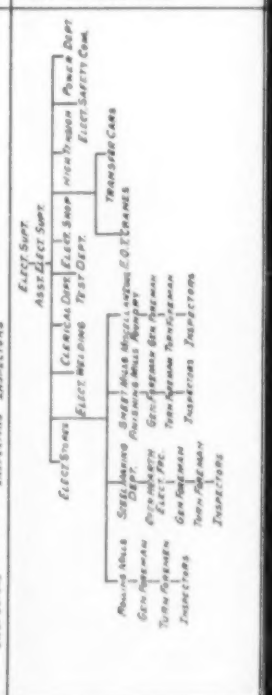
SIGNED MILL FOREMAN B-302 APPROVED

SUMMARY OF COST

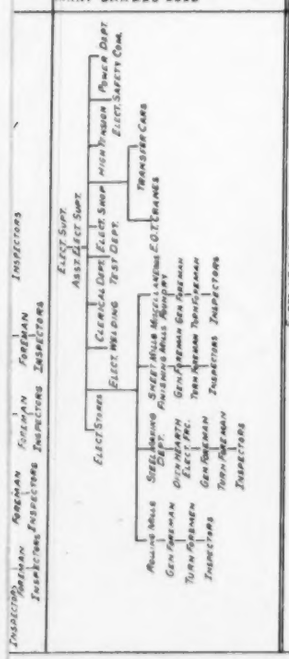
SHOPS	MATERIAL: DESCRIPTION	WEIGHT	COST	LABOR	EXPENSE	TOTAL COST	REMARKS
CARPENTER SHOP							
PATTERN "							
PAINT "							
WAGON "							
RIGGERS SAILORS "							
PIPE "							
BLACKSMITH "							
BOILER "							
MACHINE "	WELD AND REDRILL DOWEL PIN HOLE IN JACK SHAFT BRACKET AND BASE			$8 00	$3 70	$11 70	
ELECTRICAL SHOP	SHOP ORDER F-9999-T		$84 16	48 87	28 99	162 02	
					TOTAL COST (ALL SHOPS)	$173 72	

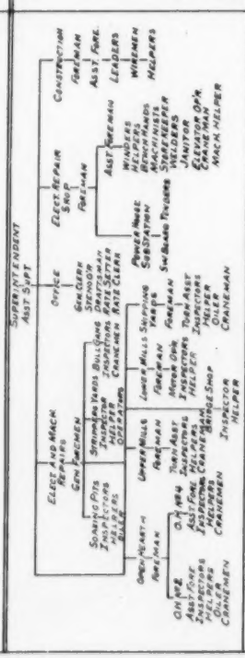
PLEASE RETURN THIS ORDER TO THE GENERAL MASTER MECHANICS OFFICE WHEN COMPLETED

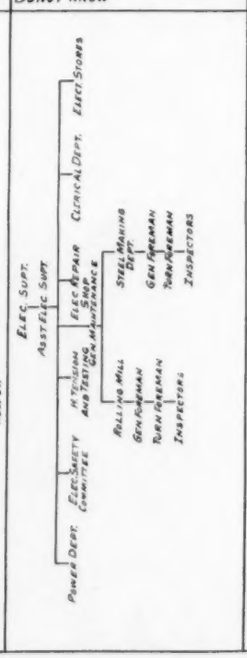
FIG. 9.

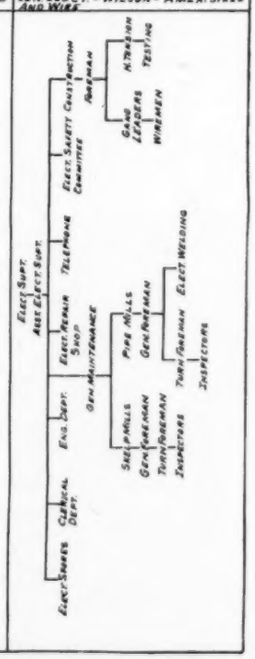
Questions	Numbers	Steel Company Numbers					
		1	2	3	4	5	6
No 2 Size of Plant	a	12000 Employees	2800 Employees	3000 Employees	2300 Employees	7500 Employees	3500 Employees
	b	Blast Frc. Steel Making, Rolling Mills, Finishing Mills	Blast Frc. Steel Making, Rolling Mills, Finishing Mills	Blast Frc Steel Making Depts, Rolling Mills	Yes	Blast Frc. Steel Making Depts., Rolling Mills, Finishing Mills	Steel Making, Rolling Mills, Finishing Mills.
	c	Finished Product – Pig Iron, Sheet Bar, Billets, Rails, Plates, Rods, Wire, Nails, Sheet & Tinplate Pipe, Ships, and Str. Work.	Pig Iron, Steel Blooms, Billets, Rods, Angles, Small Shapes, Sheets, Spikes, Coke, By Products.	Merchant Bars	Bolts - Nuts - Splice Bars - Spikes Billets - Slabs and Rods	Pig Iron, Billets, Sheet Bars, Rounds, Plates, Merchant Sheet Bars, Galvanized Sheets, Structural Shapes, Rails, Splice Bars – Tie Plates – Bolts – Nuts – Spikes	Sheets
	d	Ore To Finished Product	Ore To Finished Product	Ore To Finished Product	Ore To Finished Product	Ore To Finished Product	Openhearth To Finished Product
"A" Clerical Department	1	Writes & All Shop Orders & Requisitions	All Shop Orders and Requisitions	All Shop Orders and Requisitions	By Foreman Etc.	Foreman For Repairs Chief Eng. New Equipment	
	2	Apply Charges To Time Cards	Apply Charges To Time Cards	No	Yes	Time Sheets Having Order No. Time and Job No.	
	3	Recorded on Motor Location Card	Tabulation & Record Kept in Eng. Dept.	Yes	Yes	Motor Test & Service Record Data Card	
	4	None are Kept	Yes	Yes	Yes	Complete Cost Record Card For Each Motor	Yes By Cost Dept.
"B" Stores	1	Under Elect Supt.	Yes	No	No	Under Chief Storekeeper	Yes
	2	Elect. Dept. Man		No	No	No. Elect. Dept. Provides Order In Data	Yes
	3	Material Ordered According to 1-3 Months Turn-over	Stock Stored Based on Minimum Demand	Maximum And Minimum	To Some Extent	Yes - 30 Days and 90 Days	Yes
	4	Monthly Inventory Used as a Check	Reg. Inventory – Obsolete Mat. Scrapped	Yes	Yes	Yes - Reg. Inventory And Scrap Program	Yes
	5	Record of Stores, Card Index System Sample Card Submitted	Kardex Visible Record System Exhibits "A" and "B"	Handled Entirely By Gen. Stores	Kept By Stores Dept.	Stores Record Card With Complete Data on Part	Plant Requisitions - Inventory Cards
	6	Spare: 1 Motor & Armature For First 10 in Service - 2 for First 30 - 3 for First 100	Spare Motor or Armature For Each Size Used - Spare Control Parts	Generally Speaking Yes	For Most Everything	Spare Motors and Armatures For Each Department	Sufficient Motors - Armatures and Coils For Safe Operation
"C" Engineering Department	1	Skeleton Force	Yes	Draftsman Only	Yes Mech. And Elect.	No. Elect. Eng. Dept. - Under Gen. Eng. Dept	Yes
	2	Engineer - 3 or 4 Test Men and Draftsmen	Elect. Eng. - Asst. - 3 Eng. Draftsmen 2 Tracers and 1 Apprentice		Chief Eng. Asst. - Drafting Room		Chief Maintenance Engineer Separate Organization
	3	Layout All Switchboard and Conduit Installations	Design Sub Sta. - P.H. - Trans. Sta. - Control Cranes up to 20 Ton - Specify Mat. - Orders	Layout Systems Inside and Out Write & Elect. Specifications	All		All Designs
	4	Works with Chief Eng. Dept.	Each Dept. Handles Its Mech. Eng.	Yes	Yes		Yes
"D" Electrical Repair Shop	1	General Organization a. b. Tool Room Checker c. Card System	General Organization a. 4 Mach. - 4 Bench Hands - Helpers b. Tools in Stores Dept. Repair Shop c. Check System	General Organization a. Two b. Yes c. By Check System	General Organization a. b. Not in Elect. Dept. c. Some	General Organization a. 2 Employed In Elect Repair Shop b. c.	General Organization a. Seven b. Yes c. Card System
	2	All General Repairs	Yes	Yes	Yes	Yes	Yes
	3	Only Large Emergency Jobs	No	No.	When Necessary	No Supervisor Eng. In Special Cases	Yes - Small Percentage
	4	Coil Winding Dept. a. All Types of Coils b. Gen. Purpose Motor Coils c. Large Bars Only d. Large Dip Tank - No Vacuum Sys.	Coil Winding Dept. a. Yes b. Practically All c. Medium Oven - Air Drying Varnish d. Yes	No.	No a. Yes b. Some c. Yes d. No - Small Coils Only	No a. Yes b. No c. Yes d. No	No a. We Repair and Rewind Small Coils b. Yes c. Yes - Both d. No
	5	About 75% of this Work	Practically All - Gears Purchased Out Side Except in Emergency Cases	Armature Shafts and Bearings Only	Some	No	Yes
	6	Use a Follow-up Man	Work Orders Issued - Followed up By Shop Foreman and Asst.	By Shop Order	Do Our Own Mach. Work Follow up Man	Followed Up By Asst. Shop Foreman	Work Orders and Checker
	7	Yes	Shop Order Only - Failures Corrected By Foreman or Reported	No	Yes	Yes. See Service Card Record	Yes
	8	300 Anti-Friction Bearing Motors Out of 5000 Operating 1-3 Yrs. Show Very Little Maint. Compared To Sleeve Bearings	Where Anti Friction Have Replaced Sleeve Bearings - Records Have Been Kept - Results All New Motors Are Anti Friction.	No	No	No But Are Satisfied Anti Friction Bearings Are An Advantage on All Hard Worked Drives	No
	9	Only Piece Rate Cards	Yes - See Exhibit "C"	Yes	Yes	Yes - See Service Card	By Cost Dept Thru Work Orders
	10	Yes	No	No	No	Yes - See Sample Card	No
	11	Gang Leaders in Shop Responsible	Checked By Shop Foreman And Asst.	No	Yes	Checked By Asst Shop Foreman	Yes
"E" E.O.T. Cranes Ore Bridges Transfer Cars Car Dumpers Ore Unloaders	1	Yes	Under Mech Dept. Except Motors	No	No	Electrical Equipment Only	Yes
	2	No	Under Mech Dept. Except Motors	No	No		Transfer Cars - Yes
	3	On Cranes Yes	No	No	No		Yes
	4	Yes	No	Yes	No		Yes
	5	80% a. A Little Better Co-operation b. Better Supervisory Qualities in Foreman	Yes a. Standard Practice And Operation b. Closer Check on Safety And Condition of Cranes - Daily Reports	No	No a. b. Should Be Under Elect. Dept.	No.	Yes a. Closer Supervision Of Equipment
	6	Fire Extinguisher Only on 10%	Fire Ext. And Danger Sign On Each Crane	Safety Department	Complete Equipment	Complete Equipment	All
	7	All over 25 HP Magnetic On Cranes In Mills And Shops All Magnetic	All over 7 HP Magnetic on Cranes Mill Aux. All Magnetic	15 HP And Up Magnetic Control	15 HP And Over Magnetic	Magnetic Throout	6 HP And Over Magnetic
"F" High Tension Work and Testing	1	Yes	Under Power And Construction Dept.	No	No Universal	Construction Dept.	Yes
	2	Over Head Because Of Poor Drainage	Underground - Safety - Less Failures	Overhead And Underground	Both - Prefer Underground	Over Head	Both - Under For Mill - Over For Trans.
	3	Loop And Radial	Straight Line System	Straight Line System	Straight Line	Loop System	Both
	4	Periodic Tests On Transformer Oil Random On Equipment	Tests as Required By 2 Tech. Graduate Engineers	Yes	Random Tests	Yes	Random Tests
	5	All Types Of Test Meters	All Types of Meters	All Types of Meters	All Types of Meters	Yes	All
	6	Each Mill Is Metered	All Branches are Metered	Major Depts. Only	50%	All Circuits Metered	All Main Circuits
	7	Each Operation Is Charged Its Quota	Each Operation Is Charged Its Quota	Distributed To All Depts - Major Ass.	Ordinary	Complete Distribution Monthly	All Individual Users
"G" Power	1	Both	Power Purchased Except Eng. D.C.	All Power Is Purchased	Generated	All Power Generated	Both
	2	25 Cycle Purchased Power Served on 25 Cycle	Use 25 And 66⅔ Cycle - More Choice of Motor Speeds with 66⅔ Cycle	60 Cycle	25 Cycle - Best for Slow Speed Mill Drives	25 Cycle	Both
	3	24000 KW. in Gas Engines 30000 K.W. in Turbines	2-225 KW 230 Volt Steam Eng. Gen. 1-300 KW 230 Volt Steam Turbo-Gen.		3-2500 K.W. Gas Engines 1-5000 K.W. Steam Turbine	Steam Turbines	1-4000 K.W. Mixed Pres. Steam Turbine 2-1500 K.W. Low Pressure Steam Turbine
	4	98% From Waste Gases	Steam Boilers Fired From Waste Gas		180% Waste Gas - 25% used By Boilers	75% Waste Gases	Coal Fired Boilers
	5	6600 Volts	230 Volts D.C.	Distributed at 4160 V.A.C. and 230 V. D.C.	6600 Volts A.C.	2200 Volts A.C.	2300 Volts
	6	Both - Prefer M.G. Sets	M.G. Sets	M.G. Sets	M.G. Sets	M.G. Sets - Rotaries	Both
	7	No	One - Used In Coke Plant By Prod. Dept.	No	No	No	No
	8	M.G. Sets Manually Controlled Feeders Automatic		No	None	None	None
"H" General Maintenance	1	Ten	Three Depts.	General Repair Shop Only	One	Five	Five
	2	No	Yes	No	No	Yes	No Same Spares Used All Depts
	3	Yes	No	Operating Men Only	No	Yes Tonnage and Cost Bonus	Both
	4	No. Foreman 6 Days - Asst. Foreman Day and Night 6 Days	In Crane Division - A Foreman On Duty 7 Days - 24 Hours A Day	Foreman On Duty Week Days Only	No	Foreman on Duty 6 Days a Week	Yes
	5	Report Emergency Jobs Only Foreman Responsible for Routine Maintenance	See Exhibit			See Exhibits	
"I" Electrical Department Safety Committee	1	Yes	Yes	Yes	Yes	Yes	Yes
	2	Monthly	Once A Month	Monthly	Once A Month	Monthly	Once A Month
	3	Any Employee	7 - Depts of Elect - A Representative Chosen For Each. This Forms The Safety Committee For The Year Personal Changed Each Year	All Employees	One From Each Dept.	All Foreman	Any Employee With One Years Service
	4	By Having Every Employee Serve Either On Dept. Safety Committee Or Gang Safety Committee	Minutes of Each Meeting Given To Safety Dept. All Minutes Are Discussed By Central Com. M. And In Turn Sends Their Minutes To Each Safety Man Thru - Out Plant	Education By Collective And Individual Contact	Pamphlets And Meetings	Each Foreman Has A Group Safety Meeting Once Each Week	By Collective And Individual Contact
	5	Yes	Yes	Rules And Forms Attached	Yes	Complete Rules Covering All Depts.	Yes
"J" Electric Welding	1	Yes	No	No	No	Elect. Welding Comes Under Mech Dept	Yes
	2	—	Under Mech. Dept. Separate Foreman	Under Mech. Dept.	No		No
	3	Elect. Only	Yes		No		No
	4		No		No		No
	5	Gen. Elect. - Wgh. Mfg. - Lincoln - Home Made	Lincoln and Dualarc		General Elect. And Lincoln		Westinghouse Mfg. Co.
	6	Bethlehem - Wilson - Roebling - Im Analysis Vary With Work Done			All Kinds		Many Grades Used
No 1 Organization							

	6	7	8	9	10
	3500 EMPLOYEES	2800 EMPLOYEES	1800 EMPLOYEES	1100 EMPLOYEES	1800 EMPLOYEES
S. S	STEEL MAKING, ROLLING MILLS, FINISHING MILLS.	STEEL MAKING, ROLLING MILLS, FINISHING MILLS.	STEEL MAKING, ROLLING MILLS. FINISHING MILLS.	OPEN HEARTH FINISHING MILLS	SKELP AND PIPE MILLS
UNDS, GALVAN-ES-RAILS ETS-SPIKES	SHEETS	STRUCTURAL SHAPES	PLATES AND FLANGED HEADS	CAR WHEELS, SIDE FRAMES, BOLSTERS, BEARING HOUSINGS.	PIPE
	OPENHEARTH TO FINISHED PRODUCT	OPENHEARTH TO FINISHED PRODUCT	OPEN HEARTH TO FINISHED PRODUCT	OPEN HEARTH TO FINISHED PRODUCT	BILLETS TO FINISHED PIPE
EQUIPMENT		BY THE ELECTRICAL DEPT.	YES	ORDERS AND SPEC. FROM MAIN OFFICE	YES
NO JOB RY		BY THE ELECT. DEPT.	YES	FROM OFFICE	YES
ARD		HANDLED BY ONE MAN	YES	REPAIR AND MAINT. DEPT.	YES
CH MOTOR	YES BY COST DEPT.	SHOP ON CONTRACT BASIS	PARTIAL	REPAIR AND MAINT DEPT.	NO
	YES	YES	YES	CHIEF ELECTRICIAN SPECIFIES MATERIAL NEEDED	NO
ATA	YES			PURCHASING DEPT. BUYS THE MATERIAL	YES
	YES	DECIDED BY SHOP FOREMAN AND STOREKEEPER	YES	STORE ROOM KEEPS UNTILL NEEDED	YES - 15 DAYS CONSUMPTION
GRAM	YES	YES	YES	COST CLERK OF STORES KEEPS RECORD OF MATERIAL ONHAND AND DRAWN OUT	CLOSE EFFICIENT CHECK
PLETE	PLANT REQUISITIONS-INVENTORY CARDS	RUNNING INVENTORY CARD SYSTEM AND CHECK WITH CRANE	NO		STOCK RECORD CARD SYSTEM
& FOR	SUFFICIENT MOTORS-ARMATURES AND COILS FOR SAFE OPERATION	WELL PROTECTED WITH SPARES DEPENDING ON IMPORTANCE OF OPERATION AND HISTORY OF DEFECTANCY OF OPERATION	VARIES	SPARE CRANE MOTORS AND ARMATURES LARGE SIZES - A.C. MOTORS AS REQUIRED PARTS FOR CONTROL - STARTERS-RES.	SPARE MOTORS FOR SOME SPECIAL DRIVES - SPARE ARMATURES FOR LARGE PERCENTAGE OF DRIVES
NG DEPT	YES	NO WORK WITH GENERAL ENG. DEPT.	NO	ELECT. DEPT. CARIES NO ENG. DEPT.	YES
	CHIEF MAINTENANCE ENGINEER SEPARATE ORGANIZATION	ONE ENG. FOR GEN. TESTS, DRAWING ETC.			ENGINEER DRAFTSMAN
	ALL DESIGNS	IN DETAIL WITH CHIEF ENG. DEPT.	WORK WITH ENGINEERING DEPT.	AFTER SPEC. ARE RECEIVED CHIEF ELECT. ORDERS AND INSTALLS	GEN. LAYOUTS
	YES	VERY CLOSELY			YES
SHOP	GENERAL ORGANIZATION a. SEVEN b. YES c. CARD SYSTEM	GENERAL ORGANIZATION a. EIGHT b. YES - ELECT STOREKEEPER c. CHECK SYSTEM	GENERAL ORGANIZATION a. SEVEN b. GEN STORES c. CARD	GENERAL ORGANIZATION a. SIX BRANCH HANDS - 3 ARM WINDERS b. MACH. SHOP HAS TOOL ROOM c. CHECKS	GENERAL ORGANIZATION a. TWO b. SHOP FOREMAN c. CHECK ON ORDER
	YES	YES	YES	YES	YES BOTH AC. AND D.C.
CASES	YES - SMALL PERCENTAGE	NO	NO	NOTHING BUT INSTRUMENTS	NO
	NO. a. WE REPAIR AND REWIND SMALL COILS b. NO c. YES - BOTH d. NO	NO. a. YES b. ONLY EMERGENCY SETS c. BAKE AND ALSO USE AIR DRYING VARNISH d. WE USE DIPPING TANKS	NO a. FIELD COILS AND BRAKE COILS ONLY b. NO c. LARGE BAKE OVENS - AIR VARNISH d. NO	YES a. BRAKE - CONT. COILS ETC. b. STATER COILS ONLY c. SMALL OVEN AIR VARNISH d. NO IMPREGNATING OUTFIT	YES a. SOME EXTENT - MOSTLY EMERGENCY b. IN PART c. LARGE AND SMALL BAKING OVENS - AIR VARNISH d. YES - CONST USE AT PRESENT
	YES	PRACTICALLY ALL OF OUR MACHINE WORK	YES	YES - DO NOT CUT GEARS	NO
REMAN	WORK ORDERS AND CHECKER		NO	YES	USE JOB ORDER SYSTEM - FOLLOWED UP BY CHECKER
	YES	TAG SYSTEM ON ALL EQUIPMENT TO BE REPAIRED - CORRECT TROUBLES	YES	YES	YES
TICTION ON	NO	PREFER ANTI-FRICTION BEARINGS UNDER PROPER CONDITIONS	NO	NO DATA AVAILABLE	USE BOTH TYPE OF BEARINGS - CONVINCED ANTI-FRICTION BEST
	BY COST DEPT THRU WORK ORDERS	COVERED BY CONTRACT SYSTEM	TOTAL COSTS MILLS AND OPEN HEARTH DEPT	REPAIR & MAINT. DEPT. KEEPS RECORD OF COSTS AND SCHEDULING	HANDLED BY COST DEPT. - GEN. COSTS
	NO	CARDS - SHOW CONTRACT NOS. CHARGES	NO		NO
N	YES	CHECKED BY HEAD WINDER AND MACH.	YES	YES	TESTED BY MEN - INSPECTED BY SHOP FOR.
	YES	YES	YES	ELECTRICAL ONLY	YES
	TRANSFER CARS - YES	NOT USED	NOT USED		NONE
	YES	YES	CRANE REPAIRS ONLY	ELECTRICAL REPAIRS ONLY	YES WHEN REQUIRED
	YES	YES	YES		YES
	YES a. CLOSER SUPERVISION OF EQUIPMENT	BOTH HAVE ADVANTAGES	YES a. BETTER CONTROL OF CRANES	NO b. BETTER SUPV. BY DEPT. HEADS WHERE CRANE OPERATES	NO b. INCREASED EFFICIENCY UNDER DEPT. SUPERINTENDENT
	ALL	ALL INSPECTED TWICE YEARLY	ALL EXCEPT HAND LINE	FIRE EXTINGUISHERS ONLY	ALL ARE NECESSARY
	6 H.P. AND OVER MAGNETIC	CRANES 50 H.P. MILL AUX. ALL MAGNETIC	35 H.P. AND UP MAGNETIC	MAGNETIC CONTROL WHERE EVER POSSIBLE	25 H.P. AND UP MAGNETIC, HOWEVER APPLICATION MUST BE CONSIDERED
	YES	YES - BETWEEN TWO PLANTS	NO	NO HIGH VOLTAGE 550	YES
	BOTH - UNDER FOR MILL - OVER FOR TRANS.	OVER-HEAD	OVER HEAD	OVERHEAD	UNDER GROUND - SAFER - LESS FAILURES
	BOTH	LOOP SYSTEM	STRAIGHT LINE SYSTEM	STRAIGHT LINE SYSTEM	STRAIGHT LINE
	RANDOM TESTS	ANNUAL TESTS OF ALL OIL	YES BUT NOT A SEPARATE DEPT.	RANDOM TESTS	YES - RANDOM TESTS
	ALL	ALL	PORTABLE INDICATING AND GRAPH METER	AC. AND DC. GRAPHIC METERS	ALL
	ALL MAIN CIRCUITS	WELL COVERED	90%	MAIN PANELS HAVE METERS	EACH MILL INDIVIDUAL METERS
NERGY	ALL INDIVIDUAL USERS	COMPLETE MONTHLY REPORT KWH-TON	EACH DEPT. IS BILLED	CLOSE CHARGES	EACH USER CHARGED
	BOTH	BOTH	BOTH	BOTH	PURCHASED
	BOTH	25 CYCLE - BEST WHEN INSTALLED	60 CYCLE	60 CYCLE SUPERIOR FOR LIGHTS	25 CYCLE FOR POWER - 60 CYCLE FOR OFFICE LIGHTING
	1-4000 K.W. MIXED PRES. STEAM TURBINE 2-1500 K.W. LOW PRESSURE STEAM TURBINE	STEAM TURBINES - GAS ENGINES 3500 K.W.	STEAM - 2650 K.V.A.	1000 K.V.A. STEAM TURBINE	
	COAL FIRED BOILERS	34% BOILERS - 55% GAS ENG. 9% PUR.	NONE	NONE	
	1200 VOLTS	6600 VOLTS	2200 VOLTS	440 AC. 550 D.C.	
	BOTH	ROTARIES	BOTH	M.G. SETS ARC WELDERS ONLY	M.G. SETS
	NO	NO	NO	1 SMALL UNIT ON FIRE ALARM BATTERY	NO
	NONE	VERY LIMITED AT THIS TIME	NONE	NONE	NONE
	FIVE	FIVE	EIGHT	ONE	TWO
	NO SAME SPARES USED ALL DEPTS	YES	NO	YES	NO
	BOTH	YES	ONLY FOREMAN	NO	PIPE MILLS YES - SKELP MILLS NO
EEK	YES	GEN. FOREMAN DAY TURN ASST. GEN. FOREMAN NIGHTS SIMPLE REPORT FORM FOR EACH DIVISION	NO ONLY NIGHT TURN FOREMAN	NO FOREMAN DAILY REPORTS	YES
	YES	YES	YES	YES - CHIEF ELECT. CHAIRMAN	YES
	ONCE A MONTH	MONTHLY	MONTHLY	MONTHLY	BIWEEKLY
	ANY EMPLOYEE WITH ONE YEARS SERVICE	ALL DIVISION HEADS - EMPLOYEES REPRESENTATIVE	ANY EMPLOYEE	ALL WORKMEN	FOREMAN AND KEY MEN
AFETY	BY COLLECTIVE AND INDIVIDUAL CONTACT	WORK WITH GENERAL SAFETY DEPARTMENT	WORK UNDER GEN. DIVISION	BULLETIN BOARDS AND SHOP MEETINGS	INDIVIDUAL INSTRUCTIONS BY FOREMEN - SPECIAL MEETINGS
ELD.	YES	YES		YES	YES
DEPT	YES	YES MECH. DEPT. ALSO DOES WELDING	NO	UNDER DEPT. HEAD DOING WORK	YES
	NO	ALL WELDING UNDER ELECT. SUPERVISOR	YES	NO	NO
	NO		YES		
	NO		NO	NO DATA AVAILABLE	$20,000.00 TO $30,000.00 PER YEAR
	WESTING HOUSE MFG. Co.		GEN. ELECT. WGH MFG. ETC.	WGH MFG. Co. M.G. 1000 AMP. CAP.	GENERAL ELECT.
	MANY GRADES USED		DO NOT KNOW	VARIOUS GRADES BOTH CARBON AND METALLIC	GEN ELECT. - WILSON - AMER. STEEL AND WIRE









is also the Chief Floor Inspector matches this tag with the tag on the motor, receipting this middle section and returning it to the sender.

On receipt of the motor, the chief floor inspector prepares the Repair Shop Inspection Report, as shown in Figure (8). This report gives complete motor data, the condition of motor and the necessary repairs to put it in first class shape. This Repair Shop Inspection report is sent to the Electrical Foreman, where it is matched with the white copy of the Electrical Mill Foreman's requisition as shown in Figure (6).

The Shop Work Order, as shown in Figure (9), is then made from the Repair Shop Inspection Report and the foreman's requisition. It is made out in four copies, of which the original, first and second carbons stay in the Electric Repair Shop Foreman's desk until the job is completed and the costs compiled and recorded thereon. The fourth copy is mailed immediately to the Electrical Mill Foreman, giving him the full data of what will be required to repair the motor, the Shop Order number and advising him what other departments are working on this job. After the costs have been compiled in the space provided for summary of costs, the original is mailed to the Time Department, where it is used for compiling costs against the department listed on the order. The first carbon is then mailed to the Superintendent of the Mill to be Charged, and gives him an opportunity to check the costs of this job. The second carbon copy is mailed to the Electrical Superintendent whose organization compiles this cost data on the repair cards kept in his file, after he has noted the work done. Some advantages of this Shop Works order are that it shows the different departments working on this job, thus enabling the field to assist in expediting the work in case it is not coming through in record time, lists a complete summary of costs, such as labor, material and overhead, expended by each department, the Accounting Department numbers and complete service record.

In order to increase the incentive of the day rate men working in the Shop, a bonus or cost incentive system has been adopted and installed by a large number of manufacturing plants and steel mills, because it has increased production for a certain overhead, as well as increased the personal earnings of the workmen.

The time allowed to do a job is taken from the master rate card shown in Figure (10). This card shows the allotted time for each operation, and specifies the numerical sequence in which the operations must be performed, giving each a specific name. Three copies of these rate cards are prepared, one staying in the Electric Repair Shop file, one going to the Time Department, and the other to the Industrial Engineering Department. Before these cards are used they must be approved by the Electrical Superintendent.

These rates as shown on the master rate card are taken from time studies made by the Industrial Engineer, who comes directly under the General Superintendent's staff, or from time studies he has made on similar jobs, or from work performed on this same class of apparatus before the cost incentive system was installed.

From the master rate card (Figure 10) and the Shop Works order, (Figure 9) the shop order clerk then prepares a route card and a shop cost card as shown in Figure (11), taking the operations named and hours allotted from the master rate card. Since the front of these two cards are the same, the route card is a carbon copy. It is, therefore, necessary to have a separate set of these cards to cover work to be done on armature bearings, armatures and frames respectively. See Figures (11-A) to (11-C).

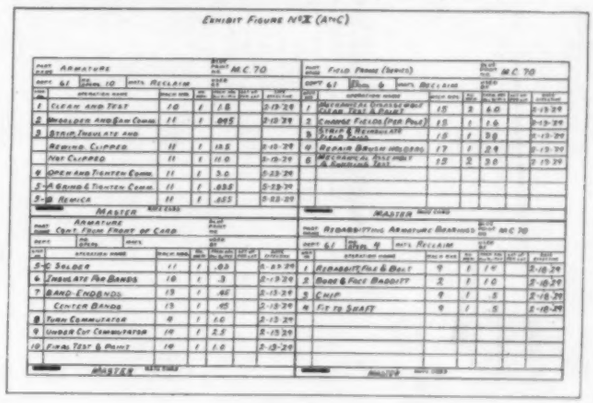


EXHIBIT FIGURE NO. X (A.I.E.E.)

ARMATURE — MC 70 — DEPT. 61 — MATL. RECLAIM

	OPERATION NAME	WORK HRS.	NO. MEN	TIME ON JOB	LAST OP.	DATE FINISHED
1	CLEAN AND TEST	.10	1	1.0		2-19-29
2	WINDLOCK AND END COILS	.11	1	.095		2-19-29
3	STRIP, INSULATE AND REWIND CLIPPED	.11	1	10.5		2-19-29
	NOT CLIPPED	.11	1	11.0		2-19-29
4	OPEN AND TIGHTEN COILS	.11	1	3.0		2-23-29
5-A	GRIND & TIGHTEN COILS	.11	1	.035		2-28-29
5-B	REVICE	.11	1	.055		3-02-29

MASTER

ARMATURE — COST FROM FRONT OF CARD

	OPERATION NAME	WORK HRS.	NO. MEN	TIME ON JOB	LAST OP.	DATE FINISHED
5-C	SOLDER	.11	1	.03		2-19-29
6	INSULATE FOR BANDS	.10	1	.3		2-19-29
7	BAND-END RISE	.13	1	.46		2-19-29
	CENTER BANDS	.13	1	.45		2-19-29
8	TURN COMMUTATOR	.9	1	1.0		2-19-29
9	UNDER CUT COMMUTATOR	.10	1	2.5		2-19-29
10	FINAL TEST & PAINT	.10	1	1.0		2-19-29

MASTER

FIELD FRAME (SERIES) — MC 70 — DEPT. 61 — MATL. RECLAIM

	OPERATION NAME	WORK HRS.	NO. MEN	TIME ON JOB	LAST OP.	DATE FINISHED
1	[illegible] CLEAN TEST & PAINT	.15	2	6.0		2-19-29
2	CHANGE FIELDS (PER POLE)	.15	1	1.6		2-19-29
3	STRIP & REINSULATE FIELD COILS	.16	1	3.8		2-19-29
4	REPAIR BRUSH HOLDERS	.13	1	.8		2-19-29
5	MECHANICAL TEST AFTER ASSEMBLY TEST	.13	2	3.0		2-19-29
6						

MASTER

REBABBITTING ARMATURE BEARINGS — MC 70 — DEPT. 61 — MATL. RECLAIM

	OPERATION NAME	WORK HRS.	NO. MEN	TIME ON JOB	LAST OP.	DATE FINISHED
1	REBABBITT FILE & BELT	.9	1	.14		2-18-29
2	BORE & FACE BABBITT	.2	1	1.0		2-18-29
3	CHIP	.9	1	.5		2-18-29
4	FIT TO SHAFT	.9	1	.5		2-18-29

MASTER

FIG. 10.

The Shop Cost card as explained above is the same as the route card, except that the back of this card is provided with two spaces, one for recording of material requisitions, including cost and requisition number and the other for a complete time card data. It is also provided with space for a summary of costs which includes total material, labor, overhead and grand total, compiled on the back of this card.

The route card is placed in a celluloid envelope and hung on a planning board, where it remains until the workman is ready to start the job. The shop cost card is placed in the Assistant Shop Foreman's file, where data from time cards and material requisitions are recorded daily until the job is complete, after which these costs are transferred to the summary cost section of the Shop Works order. It is then filed in the Electric Repair Shop, according to stock order number.

The time allowed to do a job as previously stated, is taken from the route card shown in Figure (10). When the work is started on the motor, the shop man gets the number from the motor frame, and goes to the shop office where he obtains the celluloid envelope, which contains the route card as shown in Figure (11). The shop clerk prepares and punches time card as shown in Figure (13). This card is punched out if a man changes a job during the day or at the end of a day's run, thus requiring a new card at the start of another job or another day. All jobs that pay a premium must have a time card, O.K.'d by Assistant Shop Foreman before it is punched out as completed. He makes the entry of time and bonus money on the back of the card.

If premium is earned by the workman a premium slip is made out as shown in Figure (14) and given to the man at the start of the next day, which shows that on the previous day he made so much money over the allotted time. If he disagrees with the amount shown on the slip he may discuss it with the shop foreman, who will make necessary adjustments before it is sent to the Time Department. In Figure (15) we show the "Order for Materials" requisition,

EXHIBIT FIGURE Nº XI-A

PART SYMBOL	PART NAME	QUTY. ON ORDER	ORDER NO.
M.C.70	FIELD FRAME (SERIES)	1	F-9999-T

UNIT USED ON: Nº1 FURN

CHARGE TO DEPT.: 28" MIL

REPAIRS WANTED: CHANGE AND COILS AND WELD AND JACK SHAF

OP. NO.	OPERAT
1	MECHANICAL CLEANING, TE
2	CHANGE ALL
3	STRIP AND
4	REPAIR BR
5	MECHANICAL TESTING
6	MECHANICAL MACHINE SH
7	(MECHANICAL REB MADE IN MACH. SHO
8	
9	
10	

SHOP ROUTE CARD

PART SYMBOL	PART NAME	QUTY. ON ORDER	ORDER NO.
M.C.70	FIELD FRAME (SERIES)	1	F-9999-T

UNIT USED ON	SERVICE	RECORD NO.
Nº1 FURNACE CHAIN		

CHARGE TO DEPT.	CHARGE ACCT. NO.	DATE WANTED	DATE ORDERED
28" MILL	L-724-D-3 M-726-D-3	FEBR. 18, 1930	

REPAIRS WANTED: CHANGE AND REINSULATE ALL FIELD COILS AND REPAIR BRUSH-HOLDERS WELD AND REDRILL DOWEL HOLES IN JACK SHAFT BRACKETS

REPAIRS MADE: SAME

OP. NO.	OPERATION NAME	MACH. NO.	SPECIAL TOOLS JIGS OR FIXTURES	DATE START	DATE FINISH	HRS. ALLD.	MAN'S NO. DAY	MAN'S NO. NIGHT	PIECES REJ.	PIECES SCR.	MOVE MAN'S INIT.
1	MECHANICAL DISASSEMBLING CLEANING, TEST AND PAINT	15				6.0					
2	CHANGE ALL FIELDS (PER POLE)	15				1.6					
3	STRIP AND REINSULATE ALL FIELDS	15				3.8					
4	REPAIR-BRUSHOLDERS	17				2.9					
5	MECHANICAL ASSEMBLING AND TESTING	15				3.0					
6											

SHOP COST CARD

BACK OF SHOP COST CARD

OPERATION	1				2				3				4				5			
DATE	MAN'S NO.	PCS.	HOURS	PAY	MAN'S NO.	PCS.	HOURS	PAY	MAN'S NO.	PCS.	HOURS	PAY	MAN'S NO.	PCS.	HOURS	PAY	MAN'S NO.	PCS.	HOURS	PAY
4 2	9	1	2.00	14.48													9	1	1.2	.87
		B	.5	.34													42	1	1.2	.62
	42	1	2.00	1.37																
3	B		.5	.34					68	6	4.8	3.37								
4									68	6	9.6	4.94	17	2	2.1	1.34				
8									B		1.6	.79	B		.4	.26	69	1	5.0	3.33
10					68	6	1.9	.94			15.8	B.62			2.1	1.62				
14					68	6	5.2	2.58												
16					B		1.3	.62												
18	68	1	8	.40			7.1	4.16									10	1	9.0	5.81
	B		4	.26															16.4	10.73
	1		8	.58																
	B		4	.29																
			56	4.99																

TICKET NO.	MATERIAL USED	COST
404516	2-¾"X12" Hex. Nut	.14
405612	1 Length 1-½"X1-¾" Fibre Tube	.46
405611	1-¾" Washer	.01
405610	4-¾"X3" Tap Bolts	.30
405608	16-¾"X1" Cap Screws	.64
405607	6-Rolls .11 Friction Tape ¾" W	.93
405600	1-Roll of String	.23
405599	2lbs. String Solder	.64
405598	1 Commutating Field Coil	36.65
405229	1-Roll Asbes. Tape	.27
405228	1 Roll 1" Treated Cloth Tape	.72
405227	2 Rolls 1½"X.015 Ask Tape	4.11
405226	6 rolls 1" Friction Tape	.92
404340	35 Ft. #6 Rect Bastes Cable	14.88
404118	Insulating Washers Com. Poles	.34
404119	" " Main "	1.04
404120	Commutating Pole Plates	2.60
404121	Main Pole Plates	1.82
405857	4-1¼" Nuts	.21
405856	4-1¼" Spring Washers	.84
405855	4-1¼"X5" Machine Bolts	1.80
405855		67.97
	Overhead On Labor	17.75
	Overhead On Material	3.40
		21.15

SUMMARY OF COST		TOTAL OVERHEAD	21.15
TOTAL HOURS	47.0	TOTAL MATERIAL	67.91
HOURS/PIECE		TOTAL LABOR	30.12
TOTAL COST	114.18	COST PER PC.	

11-A

EXHIBIT FIGURE No. XI-B

SHOP ROUTE CARD

PART SYMBOL	PART NAME	QUTY. ON ORDER	ORDER NO.
M.C.70	ARMATURE	1	F-9999-T

UNIT USED ON: No. 1 Fu

CHARGE TO DEPT.: 28" Mi

REPAIRS WANTED: REPAIR M / ON ACCOU / CHECK BE

OP. NO.	OPERAT
1	CLEAN & TES
2	UNSOLDER & PER. BAR
3	STRIP, INSU
4	OPEN & TIGH
5	A-GRIND C B-REMICA C-SOLDER
6	INSULATE
7	TURN COM
8	UNDERCUT
9	FINAL TEST
10	

SHOP COST CARD

PART SYMBOL	PART NAME	QUTY. ON ORDER	ORDER NO.
M.C.70	ARMATURE	1	F-9999-T

UNIT USED ON	SERVICE	RECORD NO.
No. 1 FURNACE		853-B

CHARGE TO DEPT.	CHARGE ACCT. NO.	DATE WANTED	DATE ORDERED
28" MILL	L-724-D3 M-726-D3		1-1-'30

REPAIRS WANTED: REPAIR M.C.70 ARMATURE ON ACCOUNT OF GROUNDED V-RING CHECK BEARINGS

REPAIRS MADE:

OP. NO.	OPERATION NAME	MACH. NO.	SPECIAL TOOLS JIGS OR FIXTURES	DATE START	DATE FINISH	HRS. ALLD.	MAN'S NO. DAY	MAN'S NO. NIGHT	PIECES PCS.	PIECES SCR.	MOVE MAN'S TIME
1	CLEAN & TEST	10				1.8					
2	UNSOLDER & SAW COMM. PER. BAR	10				.045					
3	STRIP, INSULATE & REWIND	11	A-CLIPPED B-NOT CLIPPED			13.5 3.					
4	OPEN & TIGHTEN COMM.	11				3.5					
5	A-GRIND COMM. BARS B-REMICA C-SOLDER	11				.035 .055 .09					
6	INSULATE & BAND	13	SET UP END BAND			0.3 0.75 0.55					
7	TURN COMM.	4				1.0					
8	UNDERCUT COMM.	14				2.5					
9	FINAL TEST & PAINT	14				1.0					
10											

BACK OF SHOP COST CARD

OPERATION	REPAIR COMM.					MACHINE V RING				HELP SOLDER				MACHINE COMM. NUT							
DATE	MAN'S NO.	PCS.	HOURS	PAY	COST	MAN'S NO.	PCS.	HOURS	PAY	MAN'S NO.	PCS.	HOURS	PAY	MAN'S NO.	PCS.	HOURS	PAY	MAN'S NO.	PCS.	HOURS	PAY
1 9	42		2.6	1.30	.62																
	42		1.4	.70	.35																
1 13						3.5		1.3	.77												
1 14	42		3.8	1.90	.76			1.9	.77												
1 15	42		5.3	2.65	1.24					44		0.4	.20	35		3.6	2.12			Varnish	
1 16	42		1.1	.55	.25							0.9	.20			3.6	2.12			Arm.	
1 18			14.2	7.10	1.01					Undercut								11		0.5	.36
1 22					1.53	3.5		0.8	.47	Comm.								B		0.1	.06
1 24					.11	B		0.3	.18	10		1.5	1.09							0.5	.42
					19.17			0.8	.45	B		0.5	.34								
														Final Test & Paint							
														10		0.8	.50				
														B		0.2	.15				
														57		0.8	.35				
														B		0.2	.09				
																1.6	1.11				

TICKET NO.	MATERIAL USED	COST
137641	4 Rolls Friction Tape	.62
137640	1 M.C.70 Mica V Ring	3.35
137637	1 Sheet Amb. Mica Band	5.76
137610	1 lb Wire, Silverine Solder	.44
137689	1 Ball 18 Strand String	.25
112031	Nut Fairing	1.01
110738	#18 Band Wire	1.53
110759	Sheet Tin	.11
		19.17
	Labor Overhead	5.18
	Material Overhead	.66

SUMMARY OF COST

TOTAL HOURS	23.9	TOTAL MATERIAL	13.17
HOURS/PIECE		TOTAL LABOR	13.82
TOTAL COST		32.83	COST PER PC.
TOTAL OVERHEAD		5.84	

37.5% Overhead

EXHIBIT FIGURE Nº XI-C

PART SYMBOL	PART NAME	QUTY. ON ORDER	ORDER NO.
M.C.70	ARMATURE BEARINGS	2	F-9999-T

UNIT USED ON: Nº 1 Fur
CHARGE TO DEPT.: 28" M
REPAIRS WANTED: REPAIR M.C. ON ACCOUNT REBABBITT

OP. No.	OPERAT
1	DISASS.& CA
2	REBABBITT, F
3	BORE & FACE
4	CHIP
5	FIT TO SHAFT
6	
7	
8	
9	
10	

SHOP ROUTE CARD

PART SYMBOL	PART NAME	QUTY. ON ORDER	ORDER NO.
M.C.70	ARMATURE BEARINGS	2	F-9999-T

UNIT USED ON: Nº 1 FURNACE
SERVICE:
RECORD NO.:
CHARGE TO DEPT.: 28" MILL
CHARGE ACCT. NO.: L-724-D3, M-726-D3
DATE WANTED:
DATE ORDERED: 1-1-'30
REPAIRS WANTED: REPAIR M.C.70 ARMATURE ON ACCOUNT OF GROUNDED V-RING REBABBITT BEARINGS
REPAIRS MADE: REBABBITTED BEARINGS

OP. No.	OPERATION NAME	MACH. NO.	SPECIAL TOOLS JIGS OR FIXTURES	DATE START	DATE FINISH	HRS. ALLD.	MAN'S NO. DAY	MAN'S NO. NIGHT	PIECES REG.	PIECES SCR.	MOVE MAN'S INIT.
1	DISASS, & CHECK BEARINGS	9			SEE Nº 5						
2	REBABBITT, FILE & BOLT	1				1.4					
3	BORE & FACE BABBITT	2				1.0					
4	CHIP	9				0.5					
5	FIT TO SHAFT	9				0.5					
6											

TOTAL COST / TOTAL HOURS / PIECE / TOTAL

SHOP COST CARD

OPERATION	2				3				5				4-5							
DATE	MAN'S NO.	PCS.	HOURS	PAY	MAN'S NO.	PCS.	HOURS	PAY	MAN'S NO.	PCS.	HOURS	PAY	MAN'S NO.	PCS.	HOURS	PAY	MAN'S NO.	PCS.	HOURS	PAY
1/15	28	2	2.5	1.61	51		1.6	1.17	28		1.0	.65								
1/18		8	0.1	.07	8		0.2	.15	8		0.1	.07								
			2.5	1.68			1.6	1.32			1.0	.72								
													28		1.6	1.03				
															3	.19				
															1.6	1.21				

Labor Overhead 37.5% 1.85
Material .15
COST 3.08

MATERIAL USED: 22# Cement A Babbitt
TICKET NO.: 11215

SUMMARY OF COST

TOTAL PIECES		TOTAL OVERHEAD	2.00
HOURS/PIECE		TOTAL MATERIAL	3.08
TOTAL COST	10.01	TOTAL LABOR	4.93
		COST PER PC.	

BACK OF SHOP COST CARD

11-C

Jan. 12-1 P.M.-30
Jan. 11-3 P.M.-30
EXHIBIT FIGURE XIII
Winder
27
Armature
#1 Furnace Chain
61 | 10 | F-9999-T | M.C.70
9 | Final Test & Paint | 1 | 28" Mill
X
72½
Foreman's O.K.
Asst. Foreman's O.K.
X

FIG. 13.

EXHIBIT FIGURE Nº XIV
PREMIUM SLIP
Nº 27
DATE 1-1 1930
YOUR PREMIUM EARNED FOR THE ABOVE DATE IS AS FOLLOWS

ORDER NO.	PART NO.	PREMIUM HRS. EARNED	HOURLY RATE	AMOUNT PREM. EARNED
F-9999-T	M.C.70	0.2	72½	$0.15
	TOTAL			

SIGNED Clerk (TIME KEEPER) APPROVED Foreman's O.K. (GENERAL FOREMAN)

FIG. 14.

EXHIBIT FIGURE Nº XV
Order for Store Material
Nº 75783
DATE 1-1 1930
FOR 28" Mill DEPT.
TO BE USED FOR #1 Furnace Chain
REPAIRS X

NO.	ARTICLE	DWG NO.
1	M.C.70-60 H.P. Mica V-Ring S# 155952	

RECEIVED BY
SIGNED Foreman or Assistant
DEPT. SUPT.:
WHEN THROUGH WITH THIS ORDER RETURN TO TIME DEPARTMENT FOR FILING.

F-9999-T
DEPT. NO. 15
ACCT. NO. 726-D-3
GROUP NO.
COMMODITY NO. 70-901
PRICE PER UNIT 3.50
TOTAL VALUE
ORDER FILLED BY

FIG. 15.

MOTOR DATA—ELECTRICAL DEPT.
EXHIBIT FIGURE Nº XVII
Dept. 28" Mill - Plant Nº2 Served FURNACE CHAIN Location Nº2-FURNACE Make WESTINGHOUSE
Type M.C. Frame No. 70 H.P. 70 Rpm 1-HOUR Issued 5-20-30 PM Volts 230 D.C. Amps. Phase
Brush W.S.M. Co. WL-50-G 2 2 1930 Amp. Per Phase Cycle Serial No. See Service Card Winding SERIES

	INITIAL TEST	TEST NO. 2	TEST NO. 3	TEST NO. 4
Date	Oct 27, 1929			
Armature	340			
Bearing	108			
Commutator	130			
Armature	349			
Bearing	132			
Commutator	130			
R.P.M. No Load	620			
R.P.M. Under Load				
R.P.M. at Rope	595			
Voltage	240			
A.C.P. Developed MAX. AVERAGE	90.1			
Room Temperature				
Motor Temperature				
Control Made	Westinghouse			
Type	Reversing-Plugging			
Time Rate	1 HOUR			
Method of Rev.	Time Limit Acc			
No. of Rev. Reads				
Type Reads	Westinghouse Type M-M			
Mech. Connection, Pinion or Pulley	17 TEETH			
Gear or Pulley	725 23-CV			
Wheel Diameter				
Pitch Diameter				
Lift, Speed Ratio				
R.P.M. at Motor	1-87.6			
Reduction Pin				

EXAMINED RECOMMENDED
CORRECTIONS MADE

REMARKS: THIS MOTOR HANDLES IT'S LOAD WITHOUT RESTRICTIONS

FIG. 17.

EXHIBIT FIGURE Nº XVI
SHOP SHIPPING TAG

TO DEPT. 28" MILL
FROM DEPT ELECT. REPAIR SHOP
SHOP ORDER NO. F-9999-T BLUE PRINT NO. M.C. 70 MOTOR
QUTY. ON ORDER 1 QUTY. SHIPPED 1
DATE SHIPPED 19
HOW SHIPPED TRUCK
SHIPPED BY FOREMAN
INSPECTED BY
RECEIVED BY
This Tag—To Be Sent With Material

TO DEPT. 28" MILL
FROM DEPT. ELECT. REPAIR SHOP
SHOP ORDER NO. F-9999-T BLUE PRINT NO. M.C. 70 MOTOR
QUTY. ON ORDER 1 QUTY. SHIPPED 1
DATE SHIPPED 19
HOW SHIPPED TRUCK
SHIPPED BY FOREMAN
INSPECTED BY
RECEIVED BY
This Tag—To Be Sent To Dep't. By Mail

TO DEPT. 28" MILL
FROM DEPT. ELECT REPAIR SHOP
SHOP ORDER NO. F-9999-T BLUE PRINT NO. M.C. 70 MOTOR
QUTY. ON ORDER 1 QUTY. SHIPPED 1
DATE SHIPPED 19
HOW SHIPPED TRUCK
SHIPPED BY FOREMAN
INSPECTED BY
RECEIVED BY
This Tag—To Be Kept By Shop Sending Material

FIG. 16.

[redacted]

ELECTRICAL DEPARTMENT

EXHIBIT FIGURE Nº XVIII

REPAIR RECORD Westinghouse MFGS. TYPE M.C. 70 DEPT. FRAME NO. See Service Card DEPT. ARMATURE NO. See Service Card

	DATE		REASON FOR REMOVAL	REPAIRS MADE		TOTAL COST	SHOP ORDER NO.	PRODUCTION LOST TIME
INSTALLED	2-23-'29	REMOVED 1-1-'30	Grounded V-Ring	Complete Overhaul		173.72	F-9999-T	1-Hour

FIG. 18.

[redacted]

EXHIBIT FIGURE Nº XIX-A
ELECTRICAL DEPARTMENT

MFG. SERIAL Nº 1345789

FRAME SERVICE RECORD Westinghouse MFGS. TYPE M.C. 70 DEPT. FRAME NO. 805 DEPT. ARMATURE NO.

	DATE	DEPARTMENT	APPARATUS	DRIVE		DATE	REASON FOR REMOVAL
INSTALLED	5-7-28	36" Mill	Bloomer	Screw Down	REMOVED	2-23-'29	Grounded Fields
	2-23-29	28" Mill	Nº 1 Furnace	Chain		1-1-'30	Grounded V-Ring

19-A

[redacted]

EXHIBIT FIGURE Nº XIX-B
ELECTRICAL DEPARTMENT

MFG. SERIAL Nº 1345789

ARM. SERVICE RECORD Westinghouse MFGS. TYPE M.C. 70 DEPT. FRAME NO. ——— DEPT. ARMATURE NO. 853

	DATE	DEPARTMENT	APPARATUS	DRIVE		DATE	REASON FOR REMOVAL
INSTALLED	2-23-29	28" Mill	Nº 1-Furnace	Chain	REMOVED	1-1-'30	Grounded V-Ring

19-B

[redacted]

MOTOR DATA—ELECTRICAL DEPT. EXHIBIT FIGURE XX

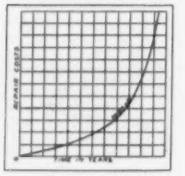
CONTROL DATA

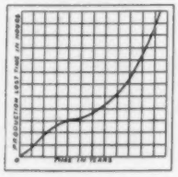
Motor No. See Enclosed Service Card Dept. 28" Mill - Plant Nº 2 - Rolling Location Nº 1-Furnace Chain
Service Chain Make Westinghouse Type M.C. 70
Frame No. 70 H.P. 70 H.P. Rating 1-Hour
Rated Volts 230 Volts D.C. Rated Speed 940 R.P.M. Current Direct
Rated Amperes Rated Temp. Rise 75° Rise Style 158295
Winding Series Drawing No. Serial No.
Brush Westinghouse WL-30-S#21939 Poles Per Phase Phase
Cycle Date Nov. 23, 1929

No. 75 Manufactured by Westinghouse D-C or A-C Control No. 572

D.C. or A.C. Primary — A.C. Secondary

Type Synchronous Class 17 588 Form No. Type Class Form No.
Volts 440 A.C. Amps. 130 Phase Volts Amps. Phase
Cycles Diagram No. 912938 Cycles Diagram No.
S.P. No. 34-D-982 Style No. 158938 S.P. No. Style No.
Mfr's Order No. C1-3655 Mfr's Order No.
Our Order No. Our Order No.
Order No. L278808 Date Installed June 5, 1928 Outline No. Date Installed
Remarks: Reversing - Passing Duty Remarks





OPEN ON THIS END

FIG. 20.

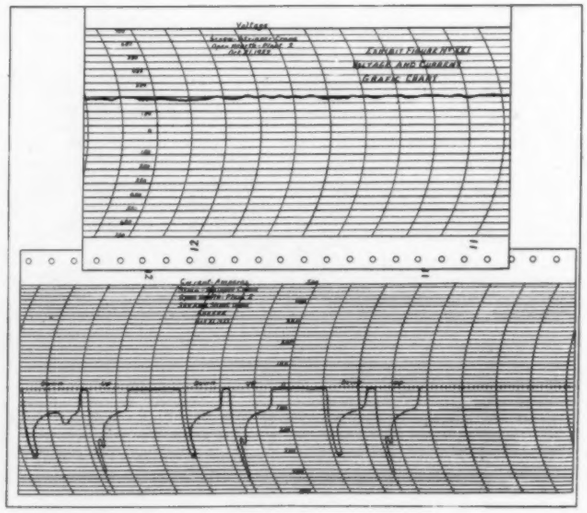


FIG. 21.

which is used to draw material from the general storeroom. This requisition has a number and is made out in duplicate. It is signed by either the Foreman or the Assistant Foreman and both copies are presented to the Storeroom when material is drawn. Before presenting to the Storeroom the number and description of material is recorded on the back of the Shop Cost card, so that the requisition, if lost, can be duplicated.

The original is mailed by the Stores Department to the Time Department, showing the commodity number and the price of the material involved. The Time Department takes record of this material for compilation of costs against the department shown and the account number. They forward the original to the Mill Superintendent, who asks the Mill Electrical Foreman to check the requisition and determine whether the charge should go against the department specified. In the meantime the carbon copy has been forwarded to the Electric Repair Shop with the cost of the material recorded. After the Electric Repair Shop has recorded these costs, they forward the carbon copy to the Mill Electrical Foreman for his files, because he returns the original to the superintendent of that department, with his O.K.

When the job is finished a shipping tag as shown in Figure (16), is made out by the order clerk. This tag is similar to the shipping tag described in Figure (7), except that its color is orange instead of blue, the orange card being used to ship material from the repair shop to the field. The perforated end of the stub is attached to the motor frame, the middle stub being mailed to the Electrical Mill Foreman receiving the material and is returned with his O.K. when the material is received. The end stub is retained by Electric Repair Shop until the receipted middle stub is received at the Electric Repair Shop.

In any well organized Electrical Department, in order that the Electrical Superintendent may at all times be fortified with well trained and experienced men along electrical lines, it is imperative that he institute an apprenticeship course in his department. The course in our judgment should cover Repair Shop, Construction Work, Installation Work, Motor Inspecting, etc. The student we believe should be started in the Electric Repair Shop and spend some 6 to 8 months in this location, from where he will be transferred to another department in accordance with the wishes or definite outline of the Superintendent. This course should occupy a period of not less than two years. In order to keep up a proper interest among the apprentices, the superintendent or some of his staff should meet with these men quarterly and go over the general program of their work, and make sure each and every man in the course feels he is getting value from the work. In addition, in many instances a plan of giving technical training one or two evenings per week, in rudiments of electrical principles, also mechanical drawing and allied subjects.

Accurate shop costs and test data are of little value to the operating and executive departments unless they are compiled in such a manner as to be readily accessible for every day use. In order that he may be able to check his costs, locate unnecessary leaks and excessive costs, caused by poor operation, unsuitable application, poor maintenance on the part of motor inspectors, etc., thereby decreasing his total shop maintenance costs and operating costs per ton of product, he must have the data available at a moment's notice. In Figures (17) and (18) we have provided a combination motor test data and Electrical Department repair record card, which will perform this function.

Figure (17) gives in detail the name of the department, name of the drive, type of drive, such as gear, chain or pulley, motor and control data, complete initial and subsequent test data taken and in fact, complete history of the installation. Figure (18) gives the history of the installation and removal for repairs of the drive motor, giving the reason for removal, repairs made, material and labor charge taken from Shop Works order shown in Figure (9), the shop order and production lost time in minutes. With this information at hand the Electrical Superintendent is able to analyze in detail the drives which are producing high maintenance and upkeep costs, causing lost time and decreasing tonnage and enabling him to recommend and assist the Chief Engineer in making changes which will save the company thousands of dollars over a period of years.

In addition to the above test data and service record cards, we have what we term an Electrical Department service record of motor parts. Figure (19) covers this card, giving the complete history of the particular part of the motor, such as frame or armature, giving each a separate card. As time goes on these cards will show the respective lengths of life the parts have given in different locations. This is another way the Electrical Superintendent has of determining the severity of respective applications and also the life of the equipment in various services. These cards are made out for each armature and each frame when it was received from the motor manufacturer, the department numbers being stamped on the end of the shaft or top of motor frame respectively where it can be easily found.

A container is necessary to hold the cards provided in Figures (17, (18) and (19) and an envelope for the purpose is provided for each drive, as shown in Figure (20). This envelope serves a double purpose, the outside being used to give a complete history of the motor and control and the name and type of drive. In the lower left hand corner a space is supplied for plotting a curve of the cost of maintaining the motor. The data for plotting this curve is taken from the back of the motor and test card, as shown in Figure (18). The right hand corner of this envelope has a space where a curve can be plotted showing the production hours lost, due to the electrical equipment on that drive. This data is

also taken from the record data card shown in Figure (18).

E. Tests

In many instances, the Electrical Superintendent makes elaborate tests covering electrical drives but after having made these tests, particularly if they are in graph form they do not take the time or trouble to lay it out from the standpoint of root mean square values, to obtain if possible, the actual heating of the equipment. We propose to present in Figure (21) what is termed the standard form of calculating the root mean square current on a special application as screw stripper crane Open Hearth Plant No. 2. We believe the curves in Figure (21) and the data in Figure (21-A) is self-explanatory.

In conclusion we wish to express our thanks and appreciation to each and every person who has in any way assisted in collecting the data, forms, etc., used in this paper. We hope that this article will at least perform the function of acting as a guide to Electrical Superintendents who are anxious to organize an efficient working department.

FIGURE XXI-A

CURRENT	I^2
0x32	0
5	25
60	3,600
100	10,000
105	11,000
110	12,100
120	14,400
140	19,600
160	25,600
200	40,000
260	67,600
230	52,900
500	250,000
0	0
5	25
90	8,100
100	10,000
110	12,100
120	14,400
120	14,400
140	19,600
160	25,600
300	90,000
0x12	0
80	6,400
100	10,000
110	12,100
120	14,400
130	16,900
160	25,600
200	40,000
260	67,600
260	67,600
0	0
0	0
90	8,100
100	10,000
100	10,000

CURRENT	I^2
120	14,400
130	16,900
140	19,600
180	32,400
320	102,400
0x11	0
80	6,400
105	11,000
110	14,400
140	19,600
160	25,600
270	72,900
350	122,500
0	0
0	0
100	10,000
120	14,400
140	19,600
160	25,600
120	14,400
105	11,000
110	12,100
120	14,400
130	16,900
140	19,600
160	25,600
300	90,000
320	102,400
	1,326,250 ÷ 118 = 15450

$\sqrt{15450} = 124$ Amp. R.M.S. Current

Flexibility of Design in the Application of Ball and Roller Bearings to General Purpose Motors

By J. L. BROWN*

After witnessing what has resulted through and incident to the work of the Special Committee on Bearings of the Association of Iron and Steel Electrical Engineers, we are able to appreciate the forethought resulting in its creation and recognize this forethought as one of many evidences of the forward-looking nature of the Association.

As the Chairman of the Committee has repeatedly impressed upon the members, the data compiled is not intended to be a standardization, but is a collection and orderly arrangement of facts relating to ball and roller bearings furnished in various classes of apparatus used by the steel mills. This 'chasing of the facts out into the open' has enabled the apparatus manufacturers to obtain a clearer perspective of the bearing situation as it relates to their apparatus and has brought out whatever lack of uniformity and interchangeability may have existed. Fortunately, speaking for the Westinghouse Company, we were able to conclude arrangements with most of the roller bearing manufacturers and so arrange our designs early in 1929 that practically complete uniformity and interchangeability could be secured in applying ball or roller bearings to our mill type motor line. The interchangeable list of bearings appeared in the Committee's report published in the June 1929 issue of the "Iron and Steel Engineer," and the following issue (July, 1929) carried our article showing in detail how this interchangeability was secured not only for new motors but for existing motors of the sleeve bearing type when converted by relatively simple measures to accommodate roller bearings.

The data compiled for general purpose motors applies to designs in production prior to 1930 and will be useful to Association members in indicating what bearings are used in motors which they have purchased antedating the new National Electrical Manufacturers' Association standard In our case the bearing sizes used for the various ratings follow more or less the recommendations made by the ball bearing manufacturers following a gathering in Cleveland in 1924 and while these bearings have given a good account of themselves as far as successfully sustaining the loads imposed is concerned, we have found it possible to secure a number of important advantages not hitherto obtained, we believe, in any line of general purpose motors. These advantages can perhaps be best illustrated by comparison with the corresponding shortcomings of the earlier designs.

When, approximately a quarter of a century ago, the then-interested parties established the proportions of ball bearings, the question of suitability of these proportions for electric motor service seems to have had but scant consideration. The 300 or medium series of ball bearing proportions is generally conceded among motor and ball bearing manufacturers to be the one best adapted for application

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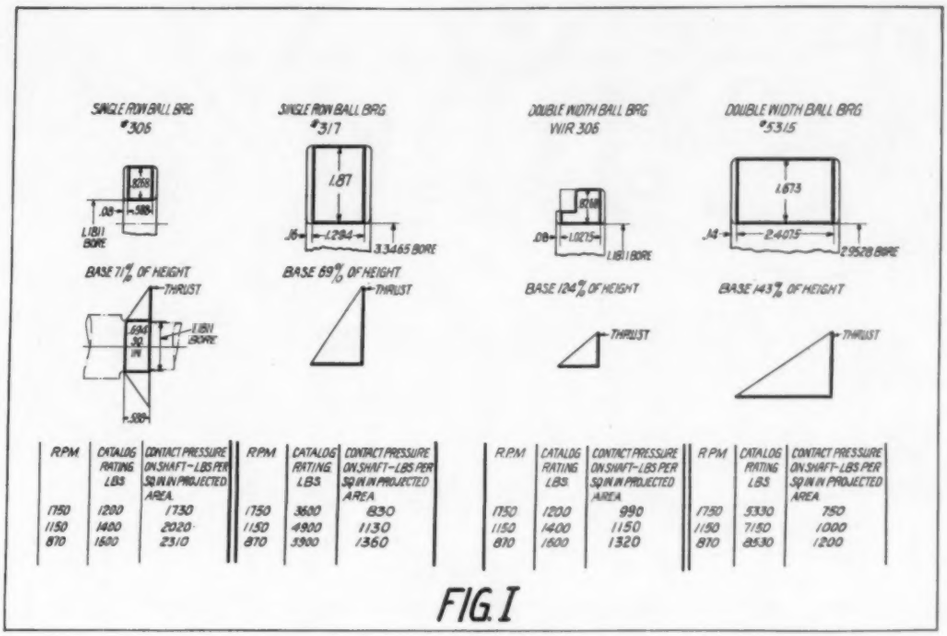

R.P.M	CATALOG RATING LBS.	CONTACT PRESSURE ON SHAFT – LBS PER SQ IN IN PROJECTED AREA
1750	1200	1730
1150	1400	2020
870	1600	2310

R.P.M	CATALOG RATING LBS.	CONTACT PRESSURE ON SHAFT – LBS PER SQ IN IN PROJECTED AREA
1750	3600	830
1150	4900	1130
870	5900	1360

R.P.M	CATALOG RATING LBS.	CONTACT PRESSURE ON SHAFT – LBS PER SQ IN IN PROJECTED AREA
1750	1200	990
1150	1400	1150
870	1600	1320

R.P.M	CATALOG RATING LBS.	CONTACT PRESSURE ON SHAFT – LBS PER SQ IN IN PROJECTED AREA
1750	5330	750
1150	7150	1000
870	8530	1200

FIG. I

to electric motors. However, our efforts in the selection of ball bearings for this purpose have convinced some of us that the choice of a suitable bearing for each case is largely a matter of adaptation and compromise.

Our experience has taught us how large a bearing to use to successfully carry a load of given character and magnitude. The problem has been to get it suitably attached to the motor. The bearing must be mounted on the shaft. The radial load carried by the bearing must be transmitted from the shaft through its contact with the bearing. The question arises "is this load carrying contact as well designed to carry the load imposed as are the internal parts of the bearing?"

Figure 1 shows that the axial length of single row ball bearing #306 in contact with the shaft is .588", giving, with the bore of 1.1811", a projected area of shaft and bearing contact of .694 square inches and resulting, for the catalog load ratings of the bearing, in very large unit pressures. Furthermore, a cross section of this bearing on account of its proportions takes the form of an upstanding rectangle with a relatively small base. There is thus present, as indicated by the triangle appearing below, a rocking tendency with consequent danger of peening the shaft at the edges of the contact area. Experience has shown that in many cases such a fit is inadequate.

It is interesting to note also in Figure 1 that in case of the single row ball bearing #317 where, because of its larger size a somewhat larger contact pressure might reasonably have been expected, this pressure is actually much lower. Evidently, in the design of single row ball bearings, shaft contacts, if considered, were deemed to be of secondary importance.

It has been the general practice to attempt to compensate for the insufficient contact with the shaft by clamping the inner race of the ball bearing axially between a shouldered portion of the shaft and a lock nut. This has proved unsatisfactory in many cases for a number of reasons. First, it is only partially effective as a method of preventing rotation of the inner bearing race on the shaft. Second, it is expensive. Third, the sharp bottoms of the threads securing the nut in place introduce high stress concentration at the point where the greatest bending movement occurs, thus greatly weakening the shaft.

Practically all other parts mounted on general purpose motor shafts such as cores, commutators, collectors or blowers have sufficient contact with the shaft to effectively resist loosening even against the torque of the motor. It would seem logical, therefore, to assume that a theoretically frictionless bearing could be readily made to prevent loosening by providing adequate shaft contact. Our success over a period of years in applying the **double width** ball and roller bearings to mill type motors without the use of lock nuts suggests that the same practice could be applied with equal success to the lighter duty general purpose motor.

The data charted in Figure 1 for double width bearings WIR-306 and 5315 respectively show the advantages of this type over the narrow type in regard to rocking tendency and unit pressure of shaft contact.

Even disregarding the question of proper contact with the shaft, the use of single row bearings throughout the range of general purpose motor sizes introduces some disadvantages. One of these is illustrated in Figure II where comparison is made between shaft extension diameters standardized by the N.E.M.A. and the bores of ball bearings having sufficient capacity for the loads imposed. The upper part of the figure shows that up to 15 H.P. at 1750 R.P.M. the bearings recommended do not greatly differ in bore from the diameter of the shaft extension but that for 25 H.P. at 1750 R.P.M. and above, there is a considerable disparity. This increases the size of the shaft stock necessary, thus

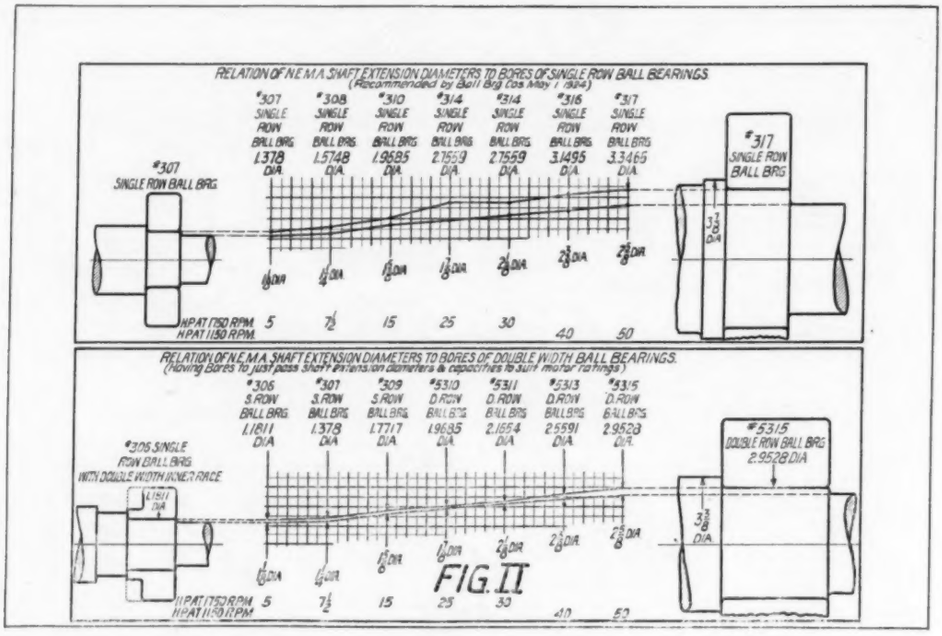
RELATION OF N.E.M.A. SHAFT EXTENSION DIAMETERS TO BORES OF SINGLE ROW BALL BEARINGS
(Recommended by Ball Brg Cos May 1 1924)
#307 SINGLE ROW BALL BRG 1.378 DIA
#308 SINGLE ROW BALL BRG 1.5748 DIA
#310 SINGLE ROW BALL BRG 1.9685 DIA
#314 SINGLE ROW BALL BRG 2.7559 DIA
#314 SINGLE ROW BALL BRG 2.7559 DIA
#316 SINGLE ROW BALL BRG 3.1495 DIA
#317 SINGLE ROW BALL BRG 3.3465 DIA
#307 SINGLE ROW BALL BRG
#317 SINGLE ROW BALL BRG
HP AT 1750 RPM 5 7½ 15 25 30 40 50
HP AT 1150 RPM
RELATION OF N.E.M.A. SHAFT EXTENSION DIAMETERS TO BORES OF DOUBLE WIDTH BALL BEARINGS.
(Having Bores to just pass shaft extension diameters & capacities to suit motor ratings)
#306 S.ROW BALL BRG 1.1811 DIA
#307 S.ROW BALL BRG 1.378 DIA
#309 S.ROW BALL BRG 1.7717 DIA
#5310 D.ROW BALL BRG 1.9685 DIA
#5311 D.ROW BALL BRG 2.1654 DIA
#5313 D.ROW BALL BRG 2.5591 DIA
#5315 D.ROW BALL BRG 2.9528 DIA
#306 SINGLE ROW BALL BRG WITH DOUBLE WIDTH INNER RACE
#5315 DOUBLE ROW BALL BRG 2.9528 DIA
HP AT 1750 RPM 5 7½ 15 25 30 40 50
HP AT 1150 RPM

FIG. II

adding considerably to the expense and as the outside diameter of the bearing also is proportionately larger, there is greater interference with the motor ventilation.

The lower part of Figure II in contrast shows how by the use of double width bearings, these difficulties may be overcome. The inner race of these bearings is of double width in every case. Up to 15 H.P. at 1750 R.P.M. a single row of balls is used, while for 25 H.P. at 1750 R.P.M. and larger ratings, two rows of balls are used. The necessity of this change from one row of balls to two rows of balls is clearly shown in Figure III. In this figure a curve is drawn giving the relative strength of N.E.M.A. standardized shafts. Four other curves are drawn showing the relative load capacities of single row and double row ball bearings at both 1750 R.P.M. and 1150 R.P.M. for bearings of the 300 series having bores just large enough to pass the various N.E.M.A. shaft diameters. The lower ball bearing capacity curve shows especially clearly that the increments of ball bearing capacity for corresponding increments of bearing bore are very considerably less than the increment of shaft strength for similar increments of shaft diameter. In other words, if single row ball bearing #309 and a shaft of 1-5/8" diameter are equally suitable in load capacity for a 15 H.P. at 1750 R.P.M. motor, the smaller sizes of bearings chosen to suit N.E.M.A. shaft sizes will have excess load capacity and the larger sizes insufficient load capacity for the corresponding motor ratings. Representing this relation, the lower bearing load capacity curve crosses the shaft strength curve at 15 H.P. at 1750 R.P.M. To obtain sufficient bearing capacity above this rating, therefore, in a bearing of size suiting the standardized shaft diameter, in other words, to keep on the left side of the shaft strength curve, it is necessary to choose double row bearings #5310, #5311, #5313 and #5315 respectively as shown.

It may be suggested that increased capacity may be obtained by using 400 series single row bearings. However, such a practice would be open to the objection of high shaft contact pressure as well as interfering with the flexibility of the design. For an understanding of this important feature, we may refer to Figure IV.

In Figure IV, the left hand vertical row of seven bearings illustrates a number of types and makes of bearing which we have applied to general purpose motors. The heavy vertical line at the left marked "Thrust Surface" represents the outer end of the outer races of the seven bearings in a uniform position—one of the requirements of interchangeability. The irregular, heavy, vertical line at the right of these bearings, however, shows lack of interchangeability comparing one bearing with another inasmuch as the thrust surfaces of the various bearing inner races are not in a uniform position.

Having established previously the desirability of employing double width inner races to obtain satisfactory mounting conditions, it will be of interest to examine the possibility for interchangeability as illustrated in the right hand vertical column of Figure IV. In this case all thrust surfaces at the right of this column are in a uniform position and at the same time all thrust surfaces at the left of this column are in a uniform position as indicated by the two heavy vertical lines. This is the condition for complete interchangeability and flexibility of design.

As an example, should the bearing load encountered at the shaft extension end of a certain motor dictate the use of a double row ball bearing, a single row bearing of the same diameter will have ample capacity for the load at the opposite end. By using in this position the single row bearing with inner race extended toward the centerline of the motor and of width equal to the double row bearing as shown uppermost in the right hand column of Figure IV, exactly the same bearing housing assembly may be used as at the shaft extension end with the economy of the less expensive bearing. Furthermore, customers with special preferences for types of bearings made only in the double width, such

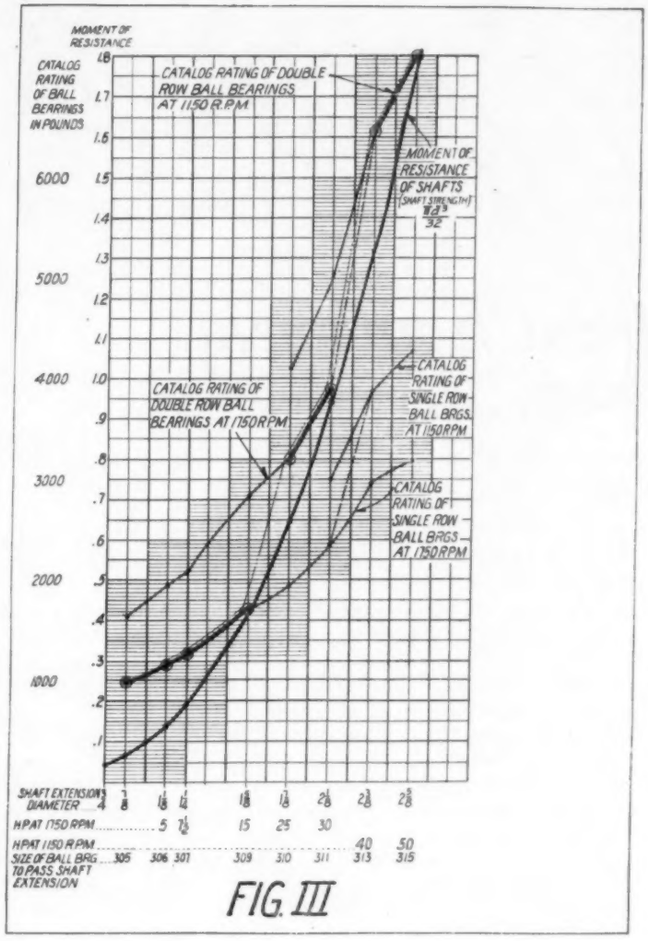

FIG. III

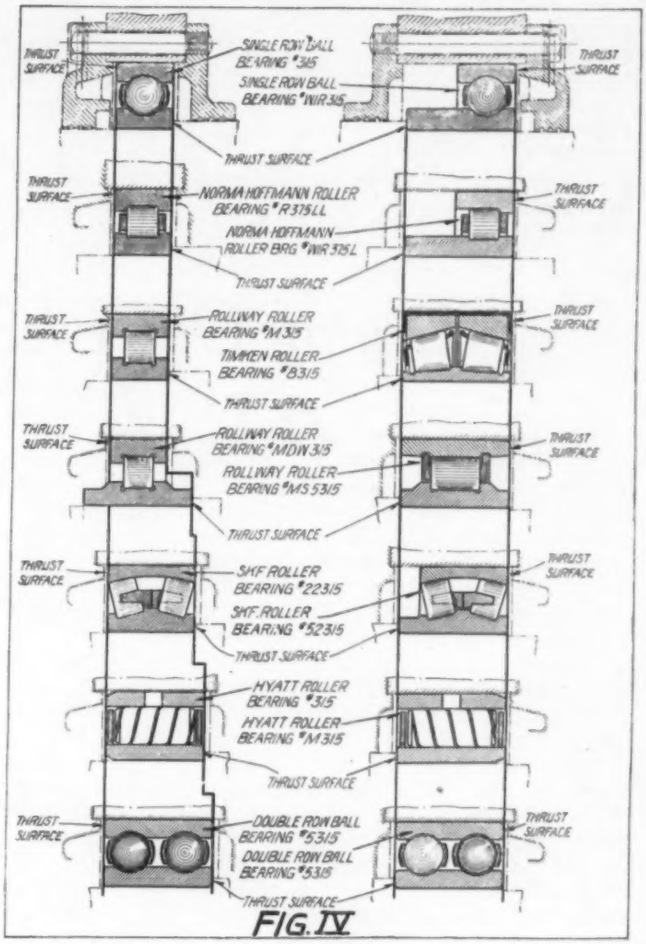
THRUST SURFACE
SINGLE ROW BALL BEARING #305
SINGLE ROW BALL BEARING #WIR 305
NORMA HOFFMANN ROLLER BEARING #R 375 LL
NORMA HOFFMANN ROLLER BRG #WIR 375 L
ROLLWAY ROLLER BEARING #M 305
TIMKEN ROLLER BEARING #B 305
ROLLWAY ROLLER BEARING #MDW 305
ROLLWAY ROLLER BEARING #MS 5305
SKF ROLLER BEARING #2205
SKF ROLLER BEARING #5205
HYATT ROLLER BEARING #305
HYATT ROLLER BEARING #M 305
DOUBLE ROW BALL BEARING #5305
DOUBLE ROW BALL BEARING #5305

FIG. IV

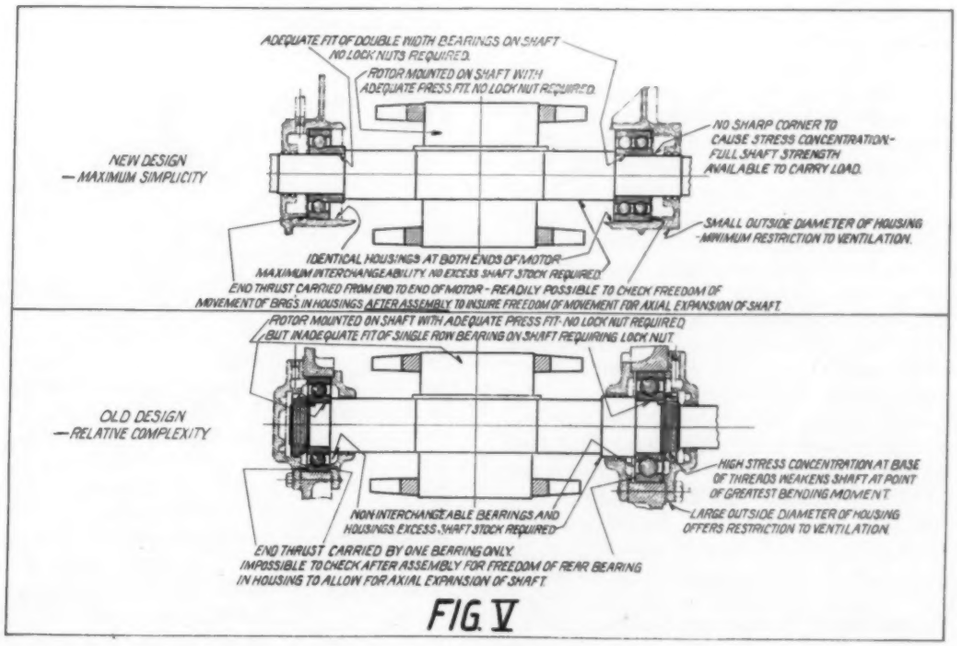
ADEQUATE FIT OF DOUBLE WIDTH BEARINGS ON SHAFT NO LOCK NUTS REQUIRED.
ROTOR MOUNTED ON SHAFT WITH ADEQUATE PRESS FIT. NO LOCK NUT REQUIRED.
NEW DESIGN — MAXIMUM SIMPLICITY
NO SHARP CORNER TO CAUSE STRESS CONCENTRATION - FULL SHAFT STRENGTH AVAILABLE TO CARRY LOAD.
SMALL OUTSIDE DIAMETER OF HOUSING - MINIMUM RESTRICTION TO VENTILATION.
IDENTICAL HOUSINGS AT BOTH ENDS OF MOTOR - MAXIMUM INTERCHANGEABILITY. NO EXCESS SHAFT STOCK REQUIRED.
END THRUST CARRIED FROM END TO END OF MOTOR - READILY POSSIBLE TO CHECK FREEDOM OF MOVEMENT OF BRGS IN HOUSINGS AFTER ASSEMBLY TO INSURE FREEDOM OF MOVEMENT FOR AXIAL EXPANSION OF SHAFT.
ROTOR MOUNTED ON SHAFT WITH ADEQUATE PRESS FIT - NO LOCK NUT REQUIRED. BUT INADEQUATE FIT OF SINGLE ROW BEARING ON SHAFT REQUIRING LOCK NUT.
OLD DESIGN — RELATIVE COMPLEXITY
HIGH STRESS CONCENTRATION AT BASE OF THREADS WEAKENS SHAFT AT POINT OF GREATEST BENDING MOMENT.
NON INTERCHANGEABLE BEARINGS AND HOUSINGS. EXCESS SHAFT STOCK REQUIRED.
LARGE OUTSIDE DIAMETER OF HOUSING OFFERS RESTRICTION TO VENTILATION.
END THRUST CARRIED BY ONE BEARING ONLY. IMPOSSIBLE TO CHECK AFTER ASSEMBLY FOR FREEDOM OF REAR BEARING IN HOUSING TO ALLOW FOR AXIAL EXPANSION OF SHAFT.

FIG. V

as the Timken or Hyatt bearings illustrated, may be readily served without delay in delivery or expensive change in design by mounting such bearings in the same Universal housing assembly, and in general, since many types and makes of bearing can be used in such a housing interchangeably, the problem of carrying spare parts is greatly simplified as almost any make of bearing can be used to replace a worn-out bearing of any other make as long as it is of sufficient load capacity.

Upper and lower views in Figure V show the older and newer designs respectively. The various disadvantages of the old and the advantages of the new will be clearly understood with the aid of the appended notations. We have made every effort to secure these advantages for our customers in new Westinghouse general purpose motors. We understand that detailed bearing data for current motor designs will be collected by the Bearings Committee and published at a later date.

Drying Out Electrical Equipment†

By WALTER H. BURR*

In turning over in my mind the things which might prove of interest to the men present, one subject seems to stand out above the others and that is, Emergency Drying of Electrical Equipment.

In this discussion, I intend to speak of emergency cases such as those resulting from a fire or flood. I will not go into any technical discussion but try and give you the benefit of actual experience under such circumstances.

Naturally, the first thing to do in case of fire is to remove any material which might prove a hazard to workmen engaged in reconditioning the electrical equipment.

No time should be lost in removing any water which may be left in the pits under the equipment. If no quicker means is available, use the fire engines and get rid of all possible. At the same time, get air lines working blowing out the conduits and all places where it is not possible to pump out the water. Conditions will vary, but it has been my experience that the work of drying out ordinary rubber or F.&W. covered wires in iron conduit is one of the serious problems. So don't stop blowing out the ducts until you have all the moisture out which is possible to remove with air. If men are available, put one gang on this work alone and start the others on the motors and generators.

In drying out ducts where it is impossible, due to length of time required, to pull in new wire, quite satisfactory results may be obtained by making up what are commonly called "salamanders" which are nothing more than metal drums about the size of oil barrels, so arranged that they can be used for heating purposes and placing a coil of ordinary pipe in this improvised heater. Connect metallic hose to each end of this coil and connect one end of this to an air line and put the other in the conduit which has previously been blown out with air. Turn on the air so that it is heated as it passes through the coil and allow it to pass through the conduit. Considerable care must be used or the insulation on the wire may be damaged due to excessive heat. Too hot a fire in the heater will burn out the coil if the air supply is shut off through this coil. With proper care, very satisfactory results may be obtained.

On auxiliary motors, I am convinced that better results can be obtained under most conditions by actually removing them to the repair shop and dismantling the equipment so the armatures and fields can be dried out separately. If drying ovens are used, be sure that provision is made for the removal of moisture. Otherwise, you will be greatly disappointed in the progress made with this drying out. Very satisfactory results can usually be obtained by placing the armatures on suitable timbers forming racks under which regular space heaters are placed. The number of space heaters available is the limit of the number of armatures which can be handled in this manner. The fields, if they are mill type motors, can usually be stacked up one above the other with strip heaters placed in each half of the frame. In the most extreme cases, mill type motors have been dried out by actually heating the frames with oil burners, but the man doing this kind of drying out must be very careful not to exceed the critical temperature of insulation in the motor and all covers must be removed to allow all moisture to escape.

In drying out D.C. generators, the fields are usually taken care of first. This may be accomplished by applying low voltage and circulating current through this winding, and at the same time, applying external heat. If necessary, box the equipment in so as to retain all heat possible. When field is in proper condition, it is usually possible to turn the generator over slowly and with armature short-circuited, apply sufficient field to circulate enough current in the armature to bring the temperature up to 75 or 80° C.

Where D.C. reversing motors are involved, after the D.C. generators have been dried out, the necessary current for drying out motors can be obtained from motor generator set.

I have learned to my sorrow that usually the commutator on the large D.C. machines are the most difficult part of the equipment to dry out. On most of these large units, the commutators are assembled with through bolts holding the front and back V rings. If the drying out does not progress as fast as it should, take out say one-half of these bolts in the commutator and apply external heat such as oil torches to the steel hub of the commutator. Protect the winding with asbestos so that it will not be ignited from the flame of the burner. I have seen the steam come out of these holes like steam out of the old fashioned tea kettle. After replacing the bolts first removed, proceed in like manner with those remaining. External heat ap-

*Elec. Supt., Lukens Steel Co., Coatesville, Pa.

†Presented before Phila. Section, A. I. & S. E. E., Apr., 1930.

plied to the face of the commutator will not as a rule bring out the moisture around the rings and through bolts.

Serious trouble has been encountered on large mill motors which have not been used for some time due to moisture condensation which has collected in the commutators, so, when in trouble due to low insulation don't forget to dry out the commutator. Do not, however, take out enough bolts to allow the commutator to get out of shape.

So far, nothing has been said regarding the method of measuring the insulation resistance or the proper resistance for the various pieces of equipment which have been dried out. A meggar should be used for this purpose and accompanying these sets are instructions which give the safe insulation resistance for various equipment.

On our 660-volt, D.C., reversing mill drive, consisting of three D.C. generators and two D.C. mill motors, with control, if the resistance drops below 300,000 ohms we get busy immediately and correct the trouble.

It is very desirable to keep a record of insulation resistance on electrical equipment, especially on large mill drives, and when any decrease is noted it should be investigated and corrected as soon as possible.

Why Arc-Weld Cranes?

By H. T. FLORENCE*

With cranes, as with all other production machines, a great deal of thought and energy has been expended in the past few years to bring them up to the high point of efficiency required by modern production schemes.

A careful analysis has naturally been required to determine those points of past types of crane construction which have done the most to attribute to whatever lack of efficiency existed in crane operation. There is no question but that one of the first points considered was higher speed, but probably the most disconcerting of all points, in view of present production methods, is the shut-down for repairs. Such things as worn out bearings, worn gears, broken rivets, acid weakened members, misalignment, etc., are the most outstanding of these difficulties, and a careful analysis shows that while in some cases failures of this type, due to the material used, did occur. they were in a great majority of cases directly traceable to methods of fabrication, and their resulting misalignment of parts. There is a very pleasing lack of evidence however, of failure of material itself in properly designed members fabricated of rolled steel, our most uniform, strongest and readily obtainable product today.

With these facts in mind it was only natural to try and determine a method of fabrication, using rolled steel wherever possible, whereby strength, rigidity and alignment of all moving parts could be assured for an indefinite period of time.

Though the electric arc-welding process has been known commercially for some twenty odd years, it was not until after the close of the world war that its use as a fabricating process accelerated rapidly. It was at this time that our Company began to take cognizance of the potentialities of the electric arc as a fabricating process. Several years later this Company started their research with metallic arc-welding as a possible method of eliminating the weaknesses of traditional methods of fabrication in crane construction.

To better comprehend the advantages that have resulted from the use of arc-welded fabrication let us consider the major units of a standard overhead traveling crane individually, and analyze in a general way the changes in design affected by the use of arc-welded construction. It was, of course, the inherent superiority of rolled steel, namely, uniformity, greater strength and greater rigidity for its weight, together with its adaptability to a method of fabrication that would insure permanent alignment of all moving parts, which gave it preeminence over other materials for use in crane construction.

The failure of crane box girders is traceable directly to the methods of joining the web plates, cover plates, chord angles, diaphragms and similar members. The working of these various parts, though slight at first, continually increases in proportion to the use of the crane until the rivets have become very loose through enlargement of the rivet holes and the wearing down of rivets. It is this breaking down of joining media which causes the failure. Though girders may be constructed of the very best of material, with the finest of workmanship, and are correct in design, failures do occur. They are not frequent, but they do exist, and many more would occur were it not for the vigilance of maintenance departments. Thus it is very evident that rolled steel is the proper material, but that the methods of fabrication left much to be desired before anything approaching permanent rigidity could be attained.

The first crane bridge box girder fabricated by the electric arc-welding process was constructed by our Company in 1926. The advantages of this modern method of fabrication were immediately apparent. Instead of plates being joined at intervals by rivets which permitted working of the parts, and necessitating removal of a large percentage of valuable metal at sections of extreme importance, all the members of the girder were fused into each other by continuous welds, making the entire girder actually one piece of steel. All tests for deflection, rigidity and alignment of the welded girder showed far superior qualities than a riveted girder of the same size, and same amount of material. The welded girder from theoretical and test standpoint was very satisfactory. The performance of our welded girders applied to all types of cranes, subjected to severe service, offer further proof of the soundness of this modern method of construction.

In welded construction it is possible to use one-fourth less material for the same strength than would be required in the usual method of fabrication. This

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is due to the fact that a great deal of material is cut out in the punching of holes for the rivets. Figure 1 shows the web plate of a crane girder punched for riveted construction. At one line it is computed that approximately 25% of the metal is removed to permit the use of rivets. In welded construction the members can be welded directly into each other without the use of a third or connecting

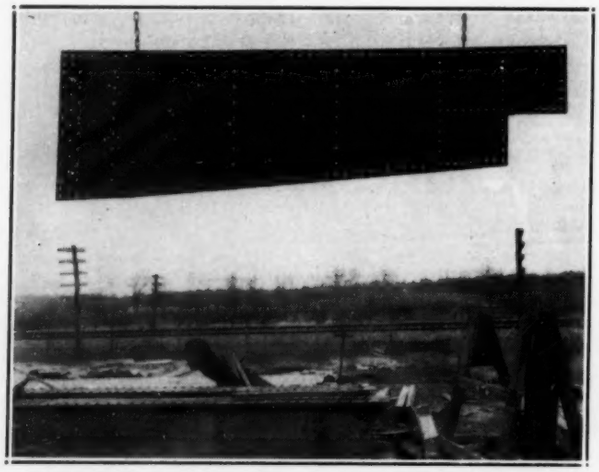

Figure 1. Note the large amount of material removed by punching for rivet holes in this section of web plate for riveted bridge girder. Because of this large amount of material removed by punching, the web plate must be approximately 25% heavier than the web plate for an arc-welded girder in order that they may have equal strength.

member as required in riveted construction. All three members must be punched in order to connect the two main members by rivets. Thus, there are twice as many connections made in riveted construction as in arc-welded construction, and therefore twice as many connections which can work loose. Figure 2 shows a girder for a 10-ton 84′ span mill crane in process of fabrication by automatic electric arc-welding. Inspection of this photograph shows that the members of this girder have not been weakened by punching as is the case illustrated in figure 1.

Another point that is often overlooked in determining the value of the welded box girder is the method of joining the diaphragms to the other members. In the riveted type of construction the diaphragms are joined only to the web plates. With the welded type of construction the diaphragms are fused into the web plates and top cover plate. Thus, in modern welded construction, one is assured that the top cover plate will bear on the diaphragms and will not act as a separate member when under load. The joining of the diaphragms to the top cover plate, as well as the web plates of the girder, and continuously instead of at intervals, as in the case of riveted construction, gives the welded girder far greater rigidity to resist torsional strains.

Due to the use of continuous welds, arc-welded box type crane girders will float in water. Thus, when cranes with this type of girders are operated in an atmosphere laden with water moisture, or acid fumes, there is no danger of corrosion inside the girders. As it is impossible to protect the interior of riveted box type girders from corrosion, the girders are often dangerously weakened from this cause, of which there is no visible evidence until the girders begin to fail. The attack of acid is generally first noticed by an abnormal loosening of rivets.

Though the advantages of arc-welded construction of crane girders are pronounced, the improvements in the design of trolleys and end trucks through the use of arc-welded construction is even more outstanding. The riveted type of trolley construction has the same shortcomings characteristic of the riveted girder. These are the constant working of parts causing looseness and finally failure of connections. This type of construction is very difficult to keep in alignment for this reason, and results in excessive gear and bearing wear. The Safety Committees will particularly welcome a method of construction which eliminates the shearing of rivets and looseness of bolts, and the dropping of rivet heads, bolts and nuts to the floor below.

There is no question but what the trolley with a one piece steel casting base will, and does insure rigidity and alignment. It necessitates, however, a great deal of care to avoid concealed defects with the added necessity of extreme caution to avoid warpage and shrinkage in a casting of these proportions.

Another point that is often overlooked, which many on first thought consider an advantage, but which in reality constitutes a rather serious disadvantage, lies in the necessity of casting various sections of a casting of this size in far greater proportions than required by strength, because of the limitations of foundry practice whereby thin sections are extremely difficult to cast. In a great many

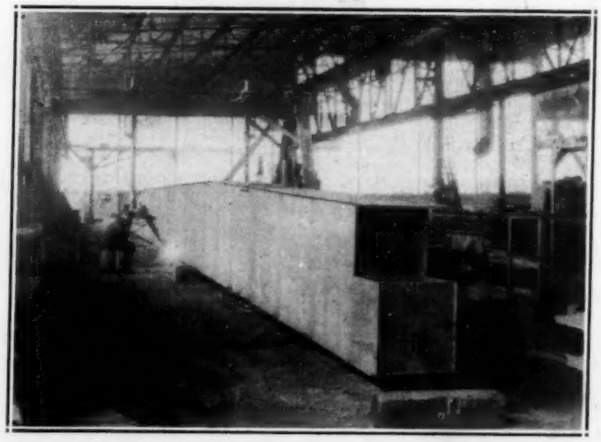

Figure 2. A 10-ton 84′ span bridge girder being continuously welded with automatic machinery.

cases the additional weight thus obtained does not increase the capacity of the trolley, because the real load-carrying parts are of sufficient size to permit them to be readily cast, but even if additional trolley capacity were obtained there would be absolutely no advantage, because the balance of the crane is figured to take care of the capacity of the crane plus the weight of the trolley, and does not take into consideration any possible added capacity of the trolley obtained by these unnecessarily large sections.

It goes even farther than this. Increased weight in the trolley frame requires a bigger trolley motor to propel it along the bridge. The combined increase in weight of the trolley frame and trolley motor makes necessary heavier girder sections. The increase in weight of girders and trolley necessitates heavier end trucks and larger bridge motor to propel the entire crane. In fact, to go even farther, this combined increase in the total weight of the crane, all of which does the user no good whatsoever, increases power consumption, makes necessary heavier crane runways and heavier columns, all of which means a greater expenditure without returns of any kind.

It is our contention that a trolley frame of rigid construction, properly designed and figured with with safety factors and overload features sufficient to meet the specifications of the most exacting of engineers, is not only the best, but the only efficient basis for construction. In a few words, added weight, if it does not increase rigidity, makes more possible permanent alignment or increase the capacity of the crane, is not only useless but inefficient.

As in the case of girder construction, rolled steel plates and structural shapes fused into each other by the electric arc, form the best possible construction of trolley frames. With the electric arc various members can be fused directly into each other, thus eliminating the necessity of a third, or connecting member as required in riveted construction. With arc-welded construction the most efficient design can be employed because the correct amount of rolled steel can be placed where it will serve most advantageously.

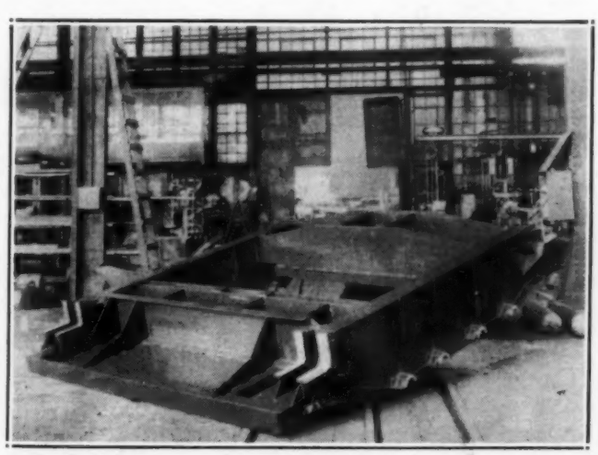

Figure 3. This frame for a 20-ton 3-motor trolley is a one piece unit of arc-welded, rolled steel construction.

A study of the trolley frame shown in figure 3 will prove conclusively to the reader the efficiency of welded steel design. If the stiffeners on the trolley frame illustrated were applied by riveting, the section of the various members would be weakened approximately 25%. This is because so much material must be cut out for rivet holes. If this trolley frame were cast, the stiffeners in many of the main members would be considerably heavier because it would be difficult to make a sound casting with sections as narrow as those of the members in the arc-welded trolley frame. The ability of the electric arc-welding process to fuse metal into metal makes the arc-welded trolley frame actually a one piece unit of rolled steel, stronger and stiffer for its weight than either a cast or riveted trolley frame.

Another excellent example of the efficient application of metal, possible only in arc-welded design, is shown in the frame of the equalizer truck, figure 4. This truck frame is also a one piece unit of rolled steel.

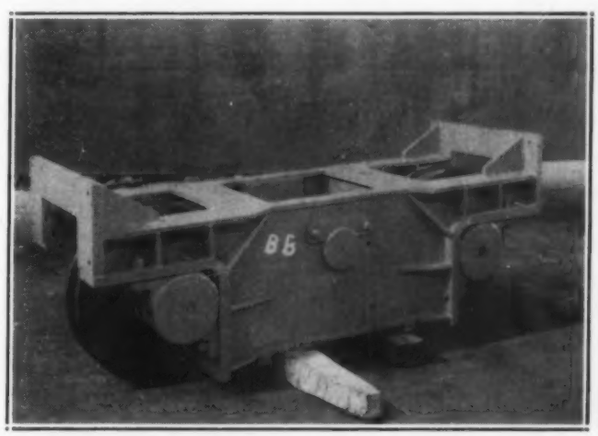

Figure 4. An equalizer truck for a 50-ton crane. Note the efficient design made possible by the use of arc-welding.

The extreme rigidity of a one piece unit of rolled steel makes possible the proper alignment of all shafts and bearings throughout the life of the crane. The weaving of crane members, caused by the loosen-

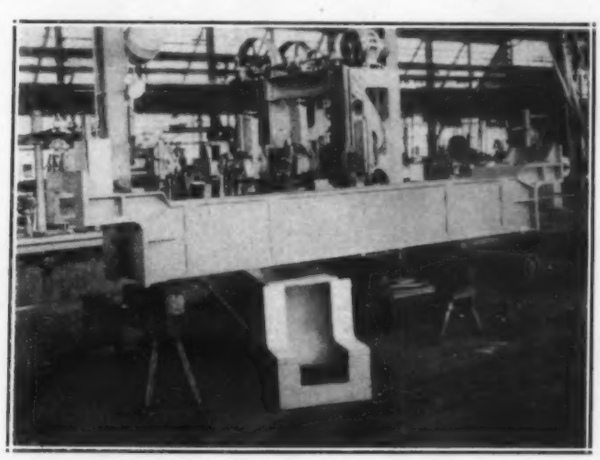

Figure 5. These one piece, rolled steel end trucks are for a 10-ton 80′ span steel mill crane. They are stronger and stiffer for their weight than either cast or riveted end trucks.

ing of connections, induces excessive wear and loss of power through misalignment of shafting and bearings.

The advantages offered by the arc-welded steel construction of trolleys and bridge girders are also apparent in the modern type of end truck construction. End trucks are long and difficult to cast. In cast end trucks there are also the possibilities of unseen weakness in the metal structure due to blow holes and sand pits. Warpage and shrinkage are also difficulties encountered in cast construction. It is also difficult to avoid spongy metal at some of the heavier sections. With arc-welding, rolled steel always uniform in strength, can be most efficiently utilized. Stiffeners of the correct size and weight may be placed where they will serve most advantageously. The same method of joining diaphragms to the webs and top cover plate as in arc-welded girder construction is also employed. Thus an end truck composed of steel plates fused into each other by the electric arc becomes a one piece unit, stronger and stiffer for its weight than any other type of construction. Figure 5 shows the simple, yet efficient, design of arc-welded steel end trucks. The automatic arc-welding of web plates to cover plate in construction of a modern one piece steel end truck is illustrated in figure 6.

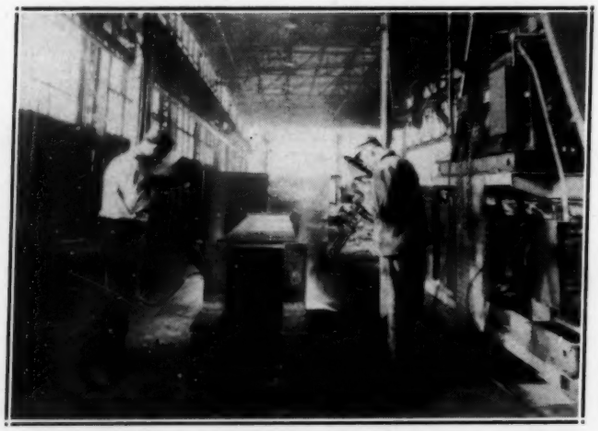

Figure 6. Fabricating a rolled steel end truck by the automatic arc-welding process.

Other details of modern crane design, such as line shaft brackets, cross walk supports, bridge drive machinery brackets and trolley rail stops, all fabricated by arc-welding, are illustrated in figure 7, which shows a completely arc-welded 10-ton 80′ span crane for steel mill service. The smooth, even surfaces, due to absence of rivet heads, gives the arc-welded crane an appearance pleasing to the eye, as well as simplifying the painting of the crane.

This new type of fabrication also permits the most efficient application of roller bearings. A recent survey shows that 76% of the engineers in charge of mill operations prefer roller bearing equipped cranes. The advantages of roller bearings are greatly enhanced when they are applied to cranes of arc-welded steel construction, for such cranes are stronger, more rigid, accelerate faster for the same motor horse power, operate smoother, require less power and stay in line.

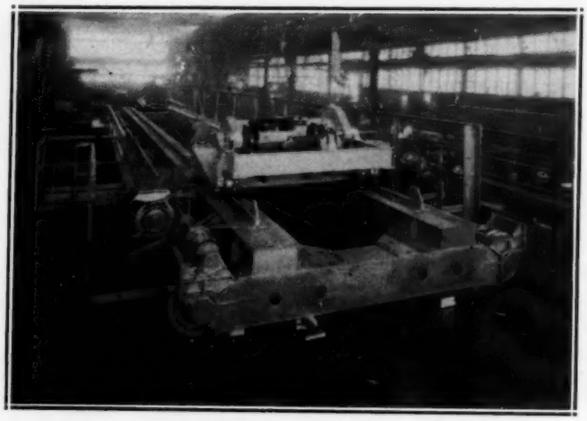

Figure 7. A steel mill crane of advanced design. Trolley, end trucks and bridge girders are of arc-welded, rolled steel construction with roller bearings applied throughout.

Steel mill men were, of course, the first to realize the tremendous advantages offered in cranes of all welded rolled steel construction. They made rolled steel. They realize its qualities of uniformity, strength and rigidity when properly applied. Figure 8 shows a typical installation of one of these modern cranes of advanced design. The performance of these cranes in various steel plants throughout the country has justified our belief, as well as the many crane users, in the superiority of arc-welded, rolled steel crane construction.

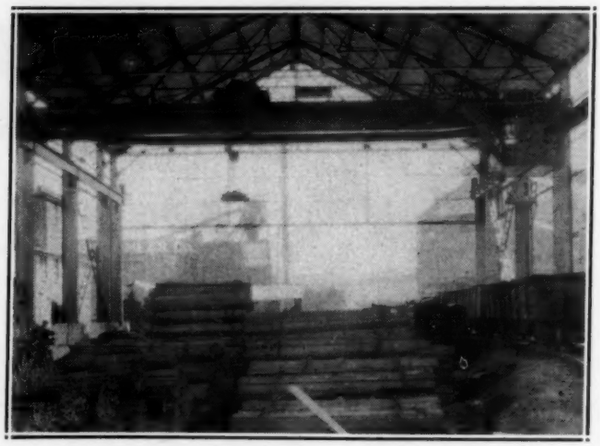

Figure 8. A typical steel mill installation of a completely arc-welded, rolled steel crane.

Reaction and Temperatures

By M. J. CONWAY*

OPEN HEARTH PRACTICE FOR THE OPEN HEARTH EMPLOYEE
LESSON NO. 4.

The following lecture is one of a series which will appear in the Iron and Steel Engineer and was prepared by Mr. M. J. Conway, Combustion Engineer of the Lukens Steel Company at Coatesville, Pa. These lectures were presented before the employees of the Open Hearth Department of the Lukens Steel Company and were illustrated by a model of an Open Hearth Furnace.

It was felt that the preparation and presentation of a series of lectures of this character would bring the employee into closer touch with the design, operation and maintenance of the furnace. At the close of each lecture, the employees were invited to question the various points touched on and these questions and answers will appear at the end of the series.

The Lukens Steel Company is to be congratulated on this particular program of education to the employee.

When these lessons have been printed in the Iron and Steel Engineer the entire course will be reprinted and bound under one cover and will be available to all interested parties at a slight cost.

In the previous papers we have followed the procedure of making steel and in this paper we are going to deal briefly with the chemistry of the process. In the purification of pig iron, which is the first of the two main steps in making steel, the four elements which are practically eliminated are silicon, manganese, phosphorus and carbon, and the principle by which this elimination is effected is that of oxidation.

In the basic open hearth process the elimination of sulphur may also take place to a greater or less extent, depending upon the amount present, but only in special cases is it considered as the principle objective. It now remains to be pointed out that this oxidation when brought about indirectly, that is, through the interactions of these elements with oxygen bearing compounds, as is the case in this process, involves, two other principles as well. These are the principles of reduction and neutralization, for it is manifestly impossible under these conditions that one substance can be oxidized without another's being reduced, and it develops, that this interaction is made possible through the immediate neutralization of the oxidized substances.

While the principles and the reactions by which the purification is brought about are, when considered separately, very simple and can be easily understood, they are somewhat difficult to follow in the actual working of the furnace, because they are here occurring simultaneously and, therefore, tend to mask each other in the effects they produce. One of the most marked of the chemical properties of metallic iron is its tendency to combine with oxygen. Even at ordinary temperatures, this tendency is very marked, as is seen from the ease and quickness with which it combines with oxygen and water to form the familiar compound known commonly as iron rust. This tendency of iron and oxygen becomes stronger as the temperature rises, so that at a temperature ranging from 500° F. to 900° F. or higher, the combination becomes very rapid, and a compound quite different from those composing rust is found.

Silicon forms but one compound with oxygen under the conditions prevailing in the open hearth, and this compound is S_1O_2 or silica. The tendency of silicon to combine with oxygen is even greater than that of iron, due to the greater heat of formation of its oxide, so that it is capable of reducing any of the oxides of the latter and upon this fact depends the elimination of this element from the molten metal. As to which of the oxides of iron is the active agent in the oxidation of silicon there can be little doubt that ferrous oxide, Fe O is the principle one that suffers direct reduction by the silicon, for, the silicon either as an alloy or a compound of iron is distributed throughout the molten mass of metal, and it is necessary that either the oxidizing agent also dissolve in the liquid or the silicon diffuse to the surface of the metal in order that the molecules may be brought into that intimate contact required to effect a reaction. The ferrous silicate is in the fluid state, for its fusion point is below that of the metal. It has a lower density than the iron, and, therefore, rises to the surface, where it temporarily forms a part of the slag. On the way to the slag it may undergo a change. Once in the slag, this ferrous silicate is capable of undergoing many changes. The first of these changes is probably due to the ability of the silica to take on additional base. Having been formed in a region where there is only a limited supply of base, the silica could not be neutralized to the extent it is capable. But now having been diffused in the slag, where there is an abundance of bases, this trisilicate may become a monosilicate with either a monoxide or a sesquioxide base. The ferrous oxide thus combined cannot act as an oxidizer, and, therefore, becomes inactive.

However, it may be made available through the action of lime and magnesia. Both these basis are capable of replacing ferrous oxide. The ferrous oxide thus liberated is now subject to reduction, and available to the bath for further use. The sources of supply of lime and magnesia are the stone charged into the furnace and the lining of the furnace itself. These alkaline earth silicates constitute the major portion of all the final slags found in the process, but these slags are never free of iron, for they hold its oxides in solution.

Manganese

While manganese combines with oxygen in several different proportions to form an equal number

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in different oxides, under the conditions that exist in the basic open hearth only one of these oxides is formed, namely, manganese oxide, or protoxide of manganese, Mno. Like silicon, the manganese in the charge being alloyed with iron, must be oxidized largely through the agency of ferrous oxide, but as silicon is capable of reducing manganese oxide, there appears little chance of oxidizing the latter until the former element has been largely eliminated from the bath. However, there is much evidence to show that at least part of the manganese finds its way into the slag long before all of the silicon has been oxidized. This fact is explained by the assumption that manganese is capable of replacing iron in the silicates of iron. With this idea in mind, it is easy to conceive the simultaneous elimination of both these elements, in which elimination the ferrous oxide plays a part of oxidizing agent, and manganese fulfills the office of the base for the neutralization of the silica. When this silicate of manganese reaches the slag, it is subjected to the same changes as are the corresponding iron oxide silicates, the manganese oxide being eventually set free by lime and magnesia. This free oxide of manganese being insoluble in the metal, remains in the slag as such, as long as the latter is rich in iron oxide, but if the slag should be depleted of its oxides, then manganeous oxide is liable to reduction, in which event the resulting metallic manganese returns to the bath. Another property of manganese, though it is of little importance in ordinary open hearth practice, may be mentioned. It refers to the ability of manganese to replace iron in combination with sulphur. Thus, all of the sulphur contained in the pig iron or steel scrap going into the furnace may be considered as being combined with this element and in the form of manganese sulphide.

Sulphur

Owing to the peculiar properties of sulphur and its oxides, they are subject to a number of conflicting influences, under the conditions of the open hearth process, that render removal of this element very uncertain. As an element, sulphur combines directly with iron to form iron sulphide and is easily oxidized to form oxide, So_3 both of which as gaseous acid anhydrides, and, when neutralized, form sulphites and sulphates, respectively. At temperatures far below the lowest working temperature of the open hearth, the sulphites and sulphates of the heavier metals, like iron, for example, decompose to form either the sulphide or the oxide of the metal and sulphur dioxide. At temperatures relatively low for furnace operation, like that of the puddling furnace, both manganese and iron sulphides are readily oxidized by the higher oxides of these elements such as $Fe_2\ O_3$ forming oxides of the metals and So_2 which escapes, as a gas, from the furnace. At the higher temperatures of the open hearth furnace there are a number of factors that operate against the elimination of sulphur in this way. Among which may be mentioned an increased tendency of iron to combine with sulphur, an increase in the reducing power of the molten iron, the fact that Co gas is capable of reducing So_2 and the probability that there is little $Fe_2\ O_3$ available to do this work. Unlike the sulphates of the heavy metals, the sulphates of the alkaline earths, such as calcium sulphate, are not decomposed by heat alone, at least not by any temperature attainable in an open hearth furnace. Therefore once the sulphur is oxidized and this combined with lime, there is some chance of its being held by the slag. However, iron is capable of decomposing the sulphate of lime, in which case the iron sulphide dissolves in the iron. As evidence that such a reaction may take place, several instances may be cited in which steel has been ruined, for the order it was intended, through charging old boiler tubes, containing much boiler scale, with the scrap. The presence of oxides in the slag tends to hold this reaction in check, so that it takes place to an appreciable degree only when the slag is burdened with an excessive amount of this sulphate, and even then it can occur only at the surfaces of contact between the metal and slag. Another source from which sulphur may be imparted to the metal is the fuel. That fuel carrying compounds of sulphur may be responsible for a portion of the sulphur content of steel is a well known fact, but through what reactions, the transfer is brought about does not appear to have been satisfactorily explained.

Phosphorus

This element is very easily oxidized, when in the free state by oxygen alone, and forms several oxides, of which only one, Phosphorus pentoxide P_{205} need be considered here, because it is the only one formed under the conditions prevailing in the open hearth. Like sulphur, phosphorus occurs in the metal as a defined compound, iron phosphide, and like silica the oxide P_2O_5 is an acid which must be neutralized as soon as it is formed. Silica has the power of replacing P_2O_5 in the ferrous phosphate, thus exposing the latter oxide to reduction, so that phosphorus is never permanently removed from the metal until the silicon has been practically all eliminated. This power of silica also accounts in part for the fact that phosphorus is not eliminated by any of the acid processes for making steel, for the proportion of this compound in the slag effectually prevents the formation of phosphate.

In the basic process the abundance of bases present in the slag is more than sufficient to satisfy the silica, so that the ferrous phosphate is not permitted to form, but on reaching the slag it is converted into a much more stable calcium phosphate. Phosphorus, therefore, is held by the slag, only so long as the latter is maintained strongly basic and at least moderately oxidizing.

Carbon

Owing to the peculiar chemical and physical properties of carbon and its oxides, the elimination of this element is distinctly different from the elements just reviewed. In that review it was pointed out that the oxidation of those elements gives compounds which are liquids under the conditions of the open hearth, that is, they are slag forming elements. But the oxidation of carbon, gives rise to the gas carbon monoxide, and owing to the conditions under which it takes place, produces what is known as the ore boil. Thus since the carbon, either as a compound or as an element, is dissolved in the metal,

and the iron oxide, in the slag, the region of greatest activity, at the beginning of the oxidation, is located near the surface of contact between the two liquids.

The generation of the carbon monoxide here gives rise to innumerable tiny bubbles of the gas, which immediately rise into the slag, but owing to the small size of the former and the viscosity of the latter, their immediate escape is hindered, so that they find their way to the surface very slowly. They thus collect in the slag, increasing its volume and imparting to it the appearance of foam. In course of time the highly oxidizing condition of the bath has disappeared with the consequent lowering of the carbon content, and both oxide and carbon are so reduced in amount that the oxidation no longer takes place rapidly and near the surface of the metal, so the slag loses its foamy appearance. Indeed, as the silicon, manganese, phosphorus and part of the carbon have been oxidized the bath of metal is becoming depleted of its reducing agents so that more and more ferrous oxide penetrates or is dissolved by the metal, which fact, together with the decomposition of the limestone, gives rise to the formation of large bodies, or bubbles, of carbon monoxide deep down in or near the bottom of the layer of metal. These bubbles rise through the metal rapidly, so that when they strike the slag; it is not given time to part, but is lifted into the atmosphere of the furnace and thrown to one side.

Lime

It is interesting to note to what extent the decomposition of the limestone on the bottoms of the furnace may contribute to this action and the elimination of the carbon. The CO_2 derived by the decomposition of the limestone as well as that from the action of the dissolved FeO, escapes to the surface as just described. Any ore that may have remained at the bottom of the furnace up to this period of the carbon elimination would also contribute to the violence of this action. At the surface of the slag the carbon monoxide discharged by the bath may burn to carbon dioxide, which escapes with the products of combustion from the flame. The boiling of the bath thus plays a very important part in the process. When the slag is thrown aside by the bubbles of gas, the metal is exposed to the action of the flame, and through this exposure is but momentary in each instance, the large number of such exposures result in the formation of a considerable quantity of ferrous oxide in this way. But the greatest benefits are derived from the agitation of the bath. It is easily seen how this agitation must result in a mixing of the slag and metal, thus increasing the area of the reaction surfaces, while the stirring effect on the metal itself should not be overlooked. Thus the metal lying near the bottom, which is the coldest and most impure, is brought upward to be heated and exposed to the oxidizing influences, so that both the temperature and composition of the bath are kept more uniform than they could otherwise be maintained.

In conclusion it should be pointed out that the effect of the carbon elimination upon the slag is to reduce its content of iron oxides. By proper regulation of the conditions this reduction of the oxides in the slag, may be brought down to a point where the total iron content of the slag will be about 10% of it's weight of which 70% will be the ferrous condition.

The order of the elimination of the elements just reviewed, with the exception of the sulphur, is the same as the order in which they have been discussed, namely, silicon, manganese, phosphorus and lastly carbon.

Some reasons why the first three elements are eliminated in this order have been mentioned under their respective headings but nothing has been mentioned that would appear to cause carbon, which is capable under proper conditions, of reducing the compounds of all these elements, to be the last element oxidized in the open hearth. The explanation for this difference in the chemical properties of carbon is connected with the fact that its reducing power increases as the temperature rises.

What has just been said should not be taken to mean that each element is completely and successively eliminated in the order mentioned, for there are laws, such as the law of mass action, for example, that operate to bring about the elimination of these elements simultaneously. The oxidation of the carbon, for example, evidently begins as the pig iron becomes hot metal and certainly before the manganese and phosphorus have been entirely disposed of.

All that should now be required in order that the chemistry of this process may be fixed clearly in mind, is a rapid review of the subject included in the second lecture of this series "Operation of the Furnace" which will now appear in a new light. To begin this review, picture a furnace in the course of operation which has received its charge of solid material for a typical heat. The first effect on this charge will be an increase of temperature. The lime, or limestone, ore and the lining of the furnace all being basic in character, will remain inactive at first and continue so, until they will have absorbed sufficient heat to raise their temperature to the point where decomposition begins. For limestone this temperature is 1560° F. while the ore will not give up its oxygen until its temperature is near the fusion point, about 2550° F. unless it comes in con-

tact with reducing agents. The absorption of heat by the ore and lime is hindered by the scrap and pig iron charged with them.

This material, being a good conductor of heat and exposed to the flame, absorbs heat very rapidly, and as soon as the temperature rises above the thermo critical range, oxidation of the iron begins, this giving rise to the formation of scale. The melting point of scale is so near to the melting point of the metal, that it remains on the surface until the metal itself begins to melt. It is understood, of course, that the impurities contained in the scrap will suffer oxidation with the iron. These fluids will trickle down over the colder material beneath and will eventually reach any ore or pig on the bottom of the furnace. Here together with additional oxide derived from the scrap and some silica, lime, etc., collected from various sources this molten scale will go to make up the first slag. This slag poor in silica but exceedingly rich in iron oxides, especially ferrous oxides, and containing some lime also, is well constituted for the work it had to do, and with the addition of hot metal or the melting of the pig iron the purification may begin at once.

From this point you should be able to continue this review through the oxidation of the carbon unaided, and in doing so, you will have fixed in mind the chemistry of the process much more firmly than if you had read the inadequately expressed thoughts of someone else.

ANALYSIS OF OPEN HEARTH MATERIALS

Name	C	Mn.	P.	S.	Si.	Cu.	Cr.	V	Fe.	Ni.
Ferro-Manganese	7.25	80.00			.50				11.25	
Ferro Phosphorus			18.56	.04	.87					
Ferro Silicon 50%	1.00		.06	.06	49.25					
Ferro Silicon 15%	1.30		.02	.06	15.00					
Ferro Chromium	1.75				1.65		67.50			
Ferro Vanadium	3.00				9.21			36.94		
Spiegel	5.00	19.50			3.75					
Pig Nickel				.05						99.00
Pig Copper						99.5				
Basic Pig	3.75	1.50	.26	.035	1.25	.10				
Acid Pig	3.75	.50	.015	.020	2.25					
Cast Iron Scrap	2.75	1.00	.50	.050	1.50					
Good Steel Scrap	.35	.50	.03	.045	.01	.08				

	SiO_2	Oxides Fe & Al		$CaCO_3$	$MgCO_3$	Fe_2O_3	Al_2O_3		
Limestone	.80	1.00		96.00	2.00				
Raw Dolomite	1.50	2.25		52.00	42.00				
Silica Sand	95.61			.50	.20	3.64	.50		

	SiO_2	Oxides Fe & Al		CaO	MgO	Insol	R_2O_3	Ignition Loss
Roasted Dolomite	5.00	5.00		51.00	35.00			4.00
Magdolite	5.00	6.50		53.00	35.00			.30
Magnesite	2.00	8.00		3.00	87.00			.30
Burned-Lime-stone				94.70	.14	1.66	1.34	

	SiO_2	as Fe.	P.	Sul.	FeO	Cr_2O_3	CaF_2	$CaCo_3$
Iron Ore	3.00	65.00	.80	.04				
Chrome Ore	9.00	Oxides			18.00	40.00		
Fluor Spar	5.00	2.50		.06			91.50	1.00

DATA RELATING TO MATERIALS USED IN FINISHING STEEL

Material Added	Element Sought	Percentage of Element in Bath	Efficiency when added in Furnace Ladle	
Pig Nickel	Ni.	.00 unless Nickel Scrap is used	98%	Never used
Ferro Chromium	Cr.	.00 unless Cr. Scrap is used	80%	
Pig Copper	Cu.	.00 unless Cu. Scrap is used	99%	
Stick Sulphur	S.	.040	Never used	66%-70%
Anthracite Slack	C.	Any desired	Seldom used	44%-50%
Pig Iron	C.	Any desired	95%	Never used
Pig Iron	Mn.	.10 to .20	50%	Never used
Ferro Manganese	Mn.	.10 to .20	50%	85%-90%
Spiegel Hot	Mn.	.10 to .20	Never used	80%-90%
Spiegel Hot	C.	.10 to any desired	Never used	100%
Ferro Phosphorus	P.	.010	Never used	75%
Ferro Silicon	Si.	.00	Never used	65%-70%
Ferro Vanadium	V.	.00 unless V. Scrap is used	Never used	70%-90%

Group Versus Individual Driven Rolling Mill Stands †

By R. H. ELLIS*

The representatives of the electrical manufacturers and others have in the past presented a number of papers dealing with the individual drive of the roll stand. Some of these papers have shown the method of calculating the power required, others have discussed quite fully the question of regulation and its resulting effect on the loops which are encountered between stands, and Mr. Badlam has pictured the history of the wide strip mill in which the individual motor drive is quite a factor. It is the purpose of this paper to point out how present mill design is taking advantage of the possibility of individual drives and show to what great extent the practice is reaching.

In the past the center of interest has been held nearly exclusively by the motor driving the working roll, but the individual drive and its resulting tandem mills have produced problems at the finishing end of the mill which are as important, perhaps more important that the drives themselves. To meet these new conditions, automatic reeling and shearing machines have been designed, and before closing, I will illustrate some of them. These machines are particularly interesting to the electrical engineer, as their success is due primarily to their special electrical features.

Considering first the main roll stand. The change from group drive to individual drive has not been a sudden one, although recent years have seen the greatest advance. The desire to simplify the cumbersome rope and large gear drives, resulting when driving all the roll stands from one steam engine, stimulated the engineer to find a means for grouping the stands together. As the electrical manufacturer designed motors of large horsepower, the mill designer replaced the engine with the electric motor. The comparatively small size of the motor permitted a number of electrical units to take up the space originally occupied by the engine. This arrangement simplified the mill gear layout, but as the motors were constant speed A.C. design, the mill stands had to be arranged so that steel was not in all the stands at one time. Thus a limited rolling schedule and product resulted, with variations of the finished material dependent upon the draft changes at points where the mill was non-continuous.

This improved conditions materially, but it did not meet the pressure being brought to bear by the insistent demand for reduction in rolling costs, for the producing of finished product of longer and heavier units, and for mills which could roll a wide variety of product with the minimum amount of roll changing.

The A.C. Adjustable speed motor used on small hot strip mills, was the first answer to the above requirement followed by the design of large D.C. motors, capable of producing high horsepower output, with 2 to 1 or even 3 to 1 speed adjustment. These D.C. motors, driven from separate generating units, were the final link in making the individual drive tandem mill a possibility. Certainly the cost of such electrical equipment is high, but the resultant increase in tonnage capacity of the mill, the reduction in space requirements, and the flexibility of the rolling schedules, amply justify the expense.

The type of mills most affected by the desire for longer and wider finished product, are the sheet, merchant, rod and strip mills and it is this type on which individual drives have become a necessity.

How far should this policy be carried? The ultimate would be a motor for each stand and a separately controlled generator for each motor, this would give the possibility of variation of speed by means of generator voltage control as well as by the motor fields. Such a scheme would not be justified, unless the power of the roll stand motors are each so high that they required the complete output of one generator for their operation. This is not uusually the case. It is more usual to group 4 or 5 motors, say the first four roughing stand motors and the last five finishing stand motors as one group and control each group from separate generators. This gives speed control by the motor fields of each motor and generator control of each group of motors.

Care should also be exercised in not carrying the individual drive idea to such an extent that it defeats one of the main advantages of the tandem mill. The advantage being that these mills result in minimum heat loss between roll stands. In the roughing train, where the feet per minute travel speed of the steel is slow, close clearances are important, and any spreading of the stands to accommodate electrical equipment would be detrimental. It is therefore, at this point in the mill, where two stands are being grouped together and driven by one motor, thus permitting the stands to be placed close together and obtaining room for the motor and necessary gear drive. Between the two stands, which are geared together, a draft of definite percentage is required. This counteracts somewhat the idea of the individual roll drive, but is least detrimental in the early part of the rolling schedule; and the resulting saving in heat loss is the greater factor to be considered.

Individual motor drive is extending farther than the tandem mill. Perhaps the ultimate is the reversing mill drive, now being built in which each roll is to be driven by a separate motor.

In this type of individual drive, interest is not centered on the ability to run the motors at differ-

† Presented before AI&SEE, February 7, 1930, Youngstown, Ohio.

* Elec. Engr., United Engineering & Foundry Company, Pittsburgh, Pa.

ent speeds, but rather on the fact that it is imperative to operate them at identical speeds with regulation values that are similar. Many mechanical improvements of the mill result. It will eliminate the pinions, which are often the cause of considerable trouble and it is expected that some variation in the diameters of the working rolls will be permissable.

By using a few pictures it is hoped to better convey an impression of the developments as mentioned, and to give you a picture of a very modern layout. The first two illustrations are to show the mechanical advantages caused by grouping. The other illustrations are to show the development to the proper combination of the group and individual drive.

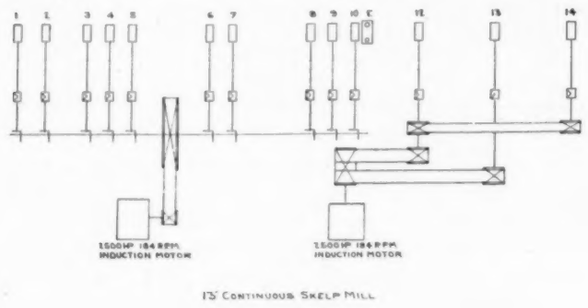

FIG. 1

Fig. 1. This picture shows a 13" Continuous mill for rolling skelp, with 10 stands. It represents an attempt to use two motors, but still results in massive gear trains and rope drives. The motors are constant speed, necessitating the roughing stands to be arranged so that steel is in no more than one group of rolls at one time, and the finishing stands are spaced that steel is free of the rolls after each pass. (Thus making relatively short Billets a necessity).

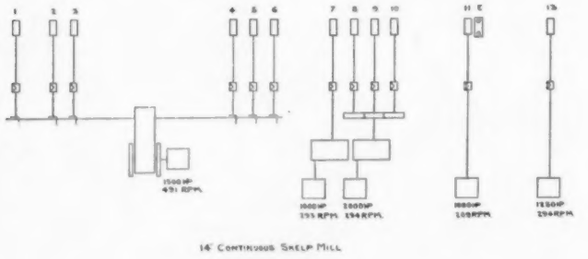

FIG. 2

Fig. 2. Is a 14" mill, designed for about the same work as the previous layout, but is interesting as more motors are utilized, thus simplifying the gear units. The total connected horsepower has increased from 5000 to 6750 HP, due to the loss of diversity of the load. This shows the group drive progress very favorably.

The most satisfactory group drive is encountered in the Bar and Billet or Skelp Mill, in which case a roll train of 10 or more stands are divided into two units, each unit driven by one motor and gear drive with a main shaft and bevel gearing to each stand. These units are usually of relatively low delivery speed and turn out a consistent product.

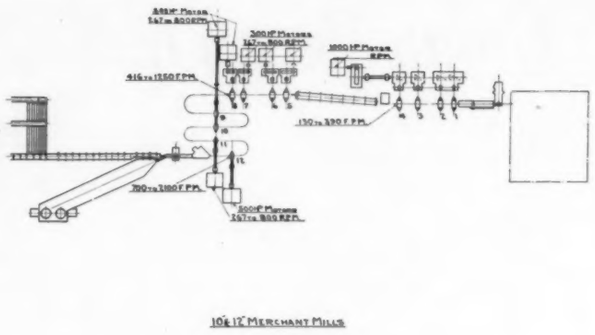

FIG. 3

Fig. 3. Illustrates a 12" and 10" Merchant Mill, rolling small rounds, squares, etc. The layout shows the three possibilities;—grouped stands,—individual stands and—stands arranged for looping.

The roughing train, four in number, are grouped together as one unit. Control of the train as a unit is provided by an adjustable speed motor, permitting the roughing train to be synchronized with the intermediate stands, without changing the roll settings. The intermediate train of 4 stands are individually driven and thus become very flexible. The next two stands are group driven from one motor and the next two stands driven from individual motors allows variation controlled by the motor speed as well as a looping floor front and back for additional fluctuations. **This is interesting in the picture, but dangerous to those standing around.**

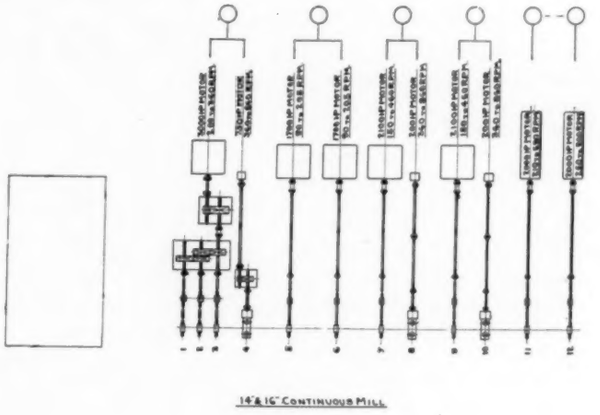

FIG. 4

Fig. 4. This illustration is to represent the modern trend and show a recent mill layout. A 14" Continuous Merchant Mill designed for a great variety of styles and sizes of sections. It represents nearly the perfect layout to which I referred earlier. The first three roughing stands are group driven but the balance are individually driven and with one exception each motor is fed from its own generator. The exception being at stand #5 and #6. The edgers driven from the same generator as the preceding stand are not handicapped by this arrangement, as their speed adjustment by field control is greater than the roll stand itself. The success of this mill with its resulting ability to handle looping of light material has been a big factor in the general acceptance of continuous individual driven mills.

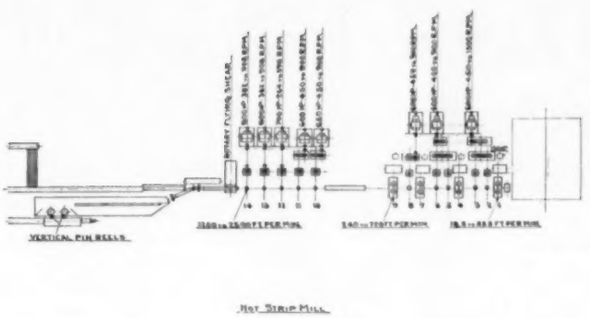

FIG. 5

Fig. 5. This illustrates the present practice in small strip mills. It shows the individual drive applied where possible with the grouping into pairs where the mechanical requirements make this an advantage.

This mill layout meets the demand for long finished units and quick change of rolling schedule. Its high delivery speed of from 1250 feet per minute to 2500 feet per minute, will permit of high tonnage records for light sections rolled.

The roughing train consists of 5-main roll stands and 4-vertical edgers, separated from the 5-stand finishing train by means of a looper to give additional variation between the units.

I would draw to your attention the location of the Rotary Flying Shear, and Pin Reels, upon which the success of the mill depends. Should these not function it would be difficult to handle the enormous length of steel which the mill is producing.

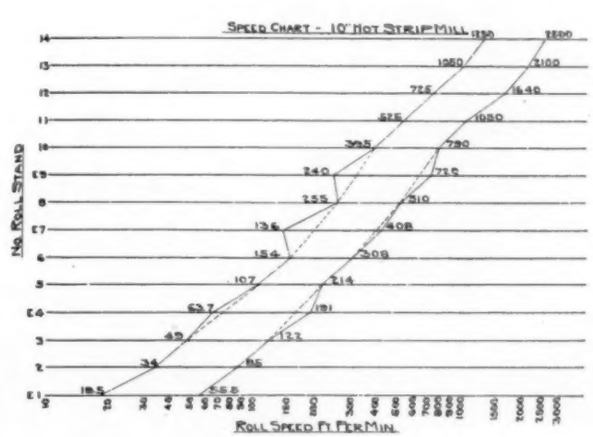

FIG. 6

Fig. 6. This shows a stand-progress chart of the foregoing mill, with the vertical ordinate indicating the roll stand and the horizontal ordinate showing the feet per minute delivery speed of the roll.

Thus is shown a maximum range of from 18½ ft. per minute on the first edger to 2500 ft. per minute on the last stand or an elongation of 135 times, with say 20% draft on the first edger, gives a total elongation of approximately 170. A 30 ft. billet results into a strip of over 5000 feet.

The problem now, is how to take care of these high speeds and enormous lengths. To do this, reels have been designed to coil the product when desired, and flying shears to cut it into Hot Bed lengths of 200 to 300 feet.

These machines are illustrated on the following slides.

Pin Reels, for reeling rods. This machine, with a jaw gripper in place of pins is used for narrow strip, where the strip can be handled on edge.

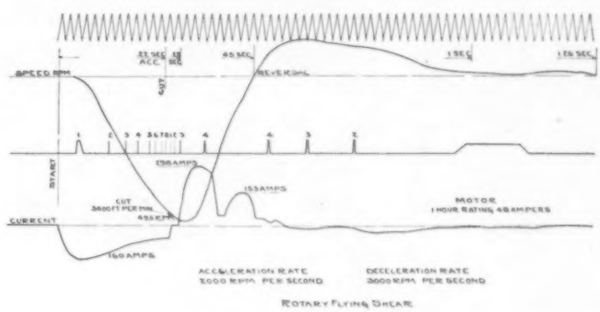

FIG. 7

Horizontal Reels of the overhung roller for narrow strip and the double housing type for wide strip from 6" to 54" wide; 1/16" to ¼" thick. Coil sizes up to 36".

Rendleman Flying Shears, for merchant, bars, rounds, etc., up to 2" flats, for hot bed lengths.

Rotary flying shears for small merchant material and wide strip to 1.4" thick.

This last shear is the very latest. It is particularly interesting to the electrical engineer, as we believe its electrical features are without comparison in the steel mill.

The knife is direct connected to the mill type motor and in about 7/8 or a revolution the motor reaches a speed of 495 R.P.M. This represents about 3000 ft. per minute flying speed at the point of contact with the steel to be cut.

In the next ¾ of a revolution the forward motion of the knife is stopped, and now since the total travel has been about 1½ revolution, the problem is to return it in ½ revolution to the starting point without damaging the machine. At the instant of mechanical reversal, reduced power is applied and the desired result is attained.

The acceleration is completed in a ¼ second the deceleration a trifle faster and the total cycle 1¼ seconds.

Group Versus Individual Driven Rolling Mill Stands†

By R. H. Ellis

Discussion

Discussed by

R. S. Shoemaker, Superintendent of Rolling Mills, American Rolling Mills Company, Middletown, Ohio.

F. W. Cramer, Chief Electrical Engineer, Republic Iron and Steel Company, Youngstown, Ohio.

S. H. McKee, Chief Engineer, Republic Iron and Steel Company, Youngstown, Ohio.

L. A. Umansky, Industrial Engineering Department, General Electric Company, Schenectady, N. Y.

G. P. Wilson, Steel Mill Engineer, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

J. A. Buell, Chief Engineer, Morgan Construction Company, Worcester, Mass.

C. C. Wales, Chief Engineer, Otis Steel Company, Cleveland, Ohio.

J. H. Van Campen, Chief Engineer, Republic Steel Corporation, Warren Plant, Warren, Ohio.

F. S. McCune.

R. H. Ellis, Electrical Engineer, United Engineering & Foundry Company, Pittsburgh, Pa.

R. M. Hussey, Superintendent of Rod and Wire Mills, Jones & Laughlin Steel Corp., Aliquippa, Pa.

F. W. Cramer: Rather than start the discussion, I would like to offer a suggestion on some discussion I would like to hear on this subject.

We, in the electrical end, talk of motors, the different types of drives. Mr. Ellis, in his paper, pointed out several other things that influence this type of drive. I would like to hear in the discussion from the operating end of the mill relative to the advantages and disadvantages on the steel itself with these variable speed drives.

In some places I know there is a very distinct advantage if we can split up the stands, put a motor on each one. In other places that advantage disappears. I know there are certain cases where there is room limitation of the mill which make it such that you just have to group certain stands, unless you revamp your whole mill, and I know there are places in the Youngstown district here where room is very scarce when it comes to putting in mills, and you pretty nearly have to make a mill to suit the room, and I would certainly enjoy hearing some discussion along those lines.

S. H. McKee: Mr. Chairman, I don't know that there is anything in particular that I can add to the very able paper as presented by Mr. Ellis. However, I am very much interested in the subject as I believe all steel plant engineers are. I know from the representation you have here today that the electrical engineers are also interested in the subject.

There is, as Mr. Cramer pointed out, another group whom I believe are as interested as either the mechanical or electrical engineers, and I refer to the operating superintendent, the roller and his crew.

It seems to me that there is a place in the picture for both the individual and group drive, and in selecting a drive for any particular installation, there are a number of factors that must be considered in making the decision. I am sure, however, that if you left the matter strictly up to the roller, and he was absolutely assured of speed control, on each of his roll stands, that he would vote for the individual drive on each stand. However, there are a number of types of heavy continuous mills in which it is pretty hard to justify the additional expenditure of the individual over the group drive, particularly on the roughing, and this may extend pretty well through the finishing.

On small continuous or semi-continuous mills I would vote with the roller, because with an individual drive on small continuous mills, the roller has greater flexibility in setting up his mill, particularly with regard to roll diameters and reductions. This is a factor in roll costs. It is also a factor in lessening the number of roll changes.

On semi-continuous mills, rolling a great variety of sections, it is also very convenient to have the individual drive for there are very few sections that require the same speeds and reductions. Also a mill of this kind is capable of absorbing new business very easily and we all know today that we get a lot of calls for new sections.

On a semi-continuous mill employing a Belgian train of strand and finishing, I believe that the roller is much better off if he has complete control of the individual stands in his strand and finishing. This is a rather hard thing to do, but if it can be arranged it allows the roller complete control of his loop and he is able to finish at a more uniform and hotter temperature, or he may be able to finish a longer piece. This will lessen, to a certain extent, the scrap loss, and will improve the yield and will be a factor in costs above per ton of steel rolled.

However, no matter what our choice may be, it is rather difficult at times, due to limited space or local conditions, to get perhaps just what we want, but on small continuous and semi-continuous mills where it is possible, I believe I would prefer the individual drive.

L. A. Umansky: It is rather difficult to contribute anything brand new to what has been already so ably presented by Mr. Ellis. I will therefore limit my few remarks to the review of the engineer-

† Presented before A. I. & S. E. E., February 7, 1930, Youngstown, Ohio.

ing features, here discussed, from an economic standpoint.

Why, may we ask, has there been, during the post-war period, such a radical change in the mill design and, as a sequence to this,—in the type of electric drive? Up to a decade or so ago, a conventional drive consisted of one big motor—seldom more—driving a number of mill stands through lineshafts, gears, belts and so forth. And now we often use a separate motor per stand.

It was quite customary for many large users of steel to place their orders several months, or even a year in advance. The rolling mills could then plan their production beforehand, rolling a large tonnage of each section for days or weeks at a time. Under such circumstances the loss of time contingent on roll changes and mill set-up was not a severe handicap. Old fashioned mill design and simple electric drives were quite in order.

Now the consumers of steel are buying "from hand to mouth." Their inventories are kept low. It is not unusual for an automobile maker to have on hand less than one week's supply: strip or sheet, rolled here, in Mahoning Valley, on Monday, may be converted at Detroit before the week is over, into a fender, running board, or an automobile body.

The steel makers may like or dislike this method of buying; in either case they must adapt themselves to the market conditions. To change orders 15-20 times in a day on an old fashioned mill and yet keep the tonnage high and the costs low—is economically impossible. Flexibility of mill design becomes a necessity; individual, adjustable speed motor drives solve the problem. While roll change may take hours, the change of speed ratio of several motors takes but a few minutes.

While it is true that an up-to-date mill, with individual motor drives, etc., may cost much more than a pre-war equipment, it actually turns steel at a lower cost per ton than was heretofore possible. The reason is simple: One such modern mill may roll a range of products that would otherwise require two or three old fashioned mills; the total investment may be actually reduced. The man power per ton is cut down; the new mill is apt to operate more hours per month than any one of the older mills.

Thus, we see, it is the market conditions, the economics, that have stimulated as usual, the technical development.

And then, after the engineers went through their task, they not only met the economic requirements but have bettered the economic situation itself.

R. S. Shoemaker: I must have been looking over the cards when that particular paragraph was read. I didn't hear Mr. Ellis read this paragraph which I had noted before in his paper. "Individual motor drive is extending farther than the tandem mill. Perhaps the ultimate is the reversing mill drive, now being built in which each roll is to be driven by a separate motor."

There is a large blooming mill equipment being built, I believe, for the Chicago district, where each roll has an individual motor. It is quite an interesting application and one is being built. I think there are several others contemplated, and possibly we could bring out some discussion on that point. Is there anybody here from the Westinghouse Company who would feel free to give us a word on that subject? It is something very new.

G. P. Wilson: Before describing the twin-motor drive for reversing mills, as requested by your Chairman, I would like to point out, in connection with Mr Ellis' paper, some of the things that have impressed me very much, as well as some of the remarks, particularly those of Mr. McKee's and Mr. Cramer's, and that is that the proper kind of equipment and successful operation of any mill is a threefold responsibility, namely, the steel manufacturer, the mill builder, and the electrical manufacturer.

I am impressed with this fact every day, in making applications to steel mill drives. It seems to me there is not quite as close co-operation between these three interested parties as there should be. I am convinced that if we had a thorough understanding of every mill design and operating problem, that we would save a considerable amount of money not only to the mill builder and steel manufacturer, but also to the electrical manufacturer. There is hardly ever a problem in mill design or mill operation but that the electrical manufacturer is often handicapped because he does not have all of the information which the steel manufacturer has nor all of the details which are in the hands of the mill builder.

I recall working on a project not very long ago which involved motors and other electrical equipment, and when it came to applying the electrical equipment, there was offered an improvement that would have saved a considerable amount of money and would, no doubt, have made a much better mill than the one which the purchaser bought, but, unfortunately, the mill had been purchased, and we were unable to adopt ideas which would have been beneficial to this steel manufacturer. So I wish to impress upon you the importance of this close co-operation, because I really believe that in the future development of the steel industry, you are going to find it very beneficial if you take into consideration all three of these interested parties before any definite step is taken.

The success of this co-operative idea has been thoroughly proven in the case of the twin-motor drive. The electrical manufacturer of the twin-motor drive had certain ideas and to incorporate these ideas required that the mill be designed to suit them. There has been a very close co-operation on this particular installation, and I must say that I believe that this is the only time there has been a definite stand taken that the mill builder, the steel manufacturer and the electrical company co-ordinated their ideas before the contract was let.

The twin-motor drive is not an entirely new idea. It has been experimented with to a very slight degree in England. It also parallels to some extent the parallel operation of generators on single armature motors. Its advantages, I am quite sure, are understood by most steel producers, electrical men, and mill builders. There is no question but that you can use two rolls more often and with less maintenance with the twin-motor drive than you can with the ordinary pinion where you have to match the rolls. You can vary the speed of the motors and use different diameter of rolls. Another advantage, and one which Mr. Ellis has mentioned, is that you eliminate the pinion and its losses.

There is no doubt but what the mill builder has

developed the pinion to a much higher degree of perfection than it was a few years ago, yet there is still some trouble and maintenance and a considerable cost for the pinion.

The pinion gear has always been a great source of annoyance, and we believe will continue to be even with improvements which have been made in its design and construction. This is partially due to the fact that the bearings will continue to wear in service and cause misalignment and result in accumulative wear of both the pinions and the bearings. These parts when they become worn also cause vibration of the entire drive. This in time will be reflected back into the reversing motor to such an extent that it may become damaged.

In addition to eliminating the defect resulting from worn bearings and gear, the twin-motor scheme will remove the necessity of keeping a spare pinion in stock, and also eliminates the elaborate lubrication system which is required for a pinion to successfully operate, thus reducing fixed charges and maintenance.

The power loss in the pinion stand, I believe, you will agree with me will vary widely with the mechanical condition of the pinion gear and bearing. Some pinions have been estimated to have a loss of as much as 5 per cent or more of the output of the mill motor. Naturally, the twin-motor drive will eliminate these losses.

The mill that is going in at the Illinois Steel Company's plant is not completely designed yet. There are certain problems that have to be worked out, and fortunately, we have the co-operation of the mill builder and the steel manufacturer in solving these problems. It is intended, however, to use standard steel mill double armature motors, thus requiring no radical change in design. A simple means of obtaining speed regulation is incorporated in the control. Due to the necessity of keeping a minimum angle at which the universal spindle operates the diameter of the motors are made as small as possible. This feature of design results in a low inertia and permits of a larger percentage of torque available for rolling steel than the single armature motor will permit. This is an advantage inasmuch as less torque is required for accelerating the twin-motor armature. This idea of co-operation, which is working so successfully on this installation, can be carried out in practically any mill that is being installed. It has not been done in the past, and I wish that all you men would think about this idea and see if you can't assist in arranging some means of co-operation which will in all cases take place between these three interested parties.

F. S. McCune: I would like to ask Mr. Ellis how far he thinks the individual roll drive has possibilities beyond the blooming mill drive. The question of unequal roll wear is one, of course, that is very important. It means special spindling or some sort of a slip arrangement, and I would just like to ask him how far he has considered that phase of the subject.

R. H. Ellis: Just how far the individual motor is going to go, we don't know, and I think we are a little inclined not to want to say. The first actual purchase of equipment is for the blooming mill. It may be the hardest job of all. If you take a non-reversing continuous mill, is should be easier to do on that type of mill than it would be on a reversing mill. The expectation is that the practice will go right along on all sizes and types of mills, The steel plant men have one aversion to it. The designer, and probably the electrical man, would like to put the motor on each side of the mill, but the steel plant roller says, "We can't use a motor on that side of the mill." He wants one side clear, for the roller to handle the steel. If you can talk your mill roller out of the idea that he has to have that side entirely clear, then I believe the individual motor on each roll will be used considerably for any and all types of mills.

When you install both motors on one side. It means that one motor has to be higher than the other. You will run into spindles that have to be built on an angle, and that causes a little additional problem in mechanical layout. It is not so bad in the blooming mill because the upper roll has to move considerably anyhow, and you take care of it with a long spindle. The twin-motor necessitates a little bit of a drop on the lower spindle, and a little extra rise on the top spindle.

Chairman Shoemaker: If we could have the strip mill, or whatever it may be, guarantee not to make any cobbles , then I think the operating men might be willing to put motors and drives on both sides, but until that time, either the mill manufacturer or we operating men can guarantee that we won't make any cobbles, especially in long-strip material, I think we will probably have to stay at one side.

C. C. Wales: I hadn't particularly intended to say anything today about drives. This matter of continuous mill drives is, of course, very interesting to our company, and we feel that the advantages and disadvantages of using different types of drives, that is, individual drives, and so on, depends entirely on a very intimate knowledge of the conditions of rolling, that is, how much reduction you are going to take, how long your slabs are going to be, what your drafts are going to be, and all that sort of thing.

I think every case is different. ,I think that the tendency to go to an extremely long slab is not in all cases a good thing, because the advantage gained in better yield on the mill is so small that it is overbalanced by the fact that if you have a cobble once in a while, a gain in yield by using a long slab is wiped out, and of course, from an operating standpoint, flexibility is important. Nowadays with many companies building wide mills, the necessity for flexibility is important. We can't roll what we want to roll. We must roll what the customer wants, and there is a feeling, as we go along, that more attention must be paid to flexibility; therefore, the individual drive is important from that standpoint.

On the other hand, there is the capital investment to consider. It is sometimes very hard to show a return on investment on slow-speed motors on roughing stands, and while it may not look like a good thing from the roller's standpoint or the operating man's standpoint, it is wiped out by the actual figures as they show up.

I think every company's case is different and the decision can only be arrived at by very thorough analysis based on a very intimate knowledge of rolling mill conditions, what you intend to roll, what graphs you propose to take, and some speculation as to what the future is going to be.

In this switchover from, you might say, multiple operation to series operation in mill, reliability is very important. It is probably the most important thing, because where you get a large number of operations in series the chain is only as strong as its weakest link, and there again I believe the thing is in favor of individual drives.

I think that is about all I have to say about it today.

J. A. Buell: I just happened into this meeting by chance, and I hardly belong in this distinguished electrical engineering crowd.

The motor-drive on any kind of a mill, of course, is a substitution for the old steam engine that used to go on the end of the shaft and that naturally was one drive for a mill, as the development of the continuous mill came forward there was a great change in the purpose of the mill. Diversity was put into the continuous mill.

The early Belgian mill that rolled pretty nearly anything from soup to nuts, of course, had enough passes to give extreme flexibility, and not much tonnage, and lots of work. Then the continuous mill came along as a single purpose mill, mostly for large tonnages, low labor, and in some cases not very hi quality, and that was partly due to the fact that the quality wasn't demanded. Any one keeping in touch with his trade has to do what the trade demands, whether he has the incentive or not.

The more recent development, possibly in the past eight or ten years, has been to introduce diversity into the continuous mill to make it more flexible in product, and to produce higher quality product and still keep the cost of conversion within about the same limits as when the quality was not as high. This I think was the beginning of the demand for separate drives on the continuous mills.

This started on the finishing ends first where the speeds were high, where gear troubles developed, and in pretty nearly all of the early continuous mills the finishing ends were driven with belts which caused a good bit of trouble and which were limited in horsepower to some extent. The more recent continuous mills, delivering up as high as 4,000 feet, are entirely gear driven, if not driven with individual motors.

One of the first reasons for putting individual drives on the finishing end was the fact that the higher speed motors were smaller, were cheaper and could be grouped closer together. In the first part of the mill at the roughing end, where you have comparatively low speeds it is impossible to get a motor driving direct on the No. 1 stand and this introduces, usually, a bigger gear reducer than if it is driven through a lineshaft.

The relationship between the motors has to be very closely regulated, and the regulating devices that have been developed by electrical manufacturers are very close and accurate in regulation but have to be set, and the old-time mill men didn't want quite so much apparatus to look after. I know one old rolling mill man who has been in the game forty years, I guess, and is about through. He said that they were getting so many "hickies" on the mills that he could hardly keep up with them any more, and, of course, when you have sixteen to twenty stands, and have that many separate regulating devices, it does introduce a problem of correlating each stand to the one in front and behind it. In some mills the product is flexible enough to allow a loop and have a little come and go. In the other mills where the product is stiff during the early reductions, pushes and pulls between stands always affect the finished product in section.

How far the introduction of the individual drives will go is still a question. It is partly a question of economics—the driving of five to seven stands, or four to seven stands in the early part of a mill with a gear drive is without question cheaper in the first installation, and that has to be considered. It is probably cheaper in upkeep. The introduction of heavier work per stand is a factor in the introduction of individual drive motors because of the gears. Gears, with the materials we have to make them out of nowadays, are limited in how much horsepower you can put through a pair of gears on a spiral bevel drive. Some of these drives are taking up to possibly 2500 horsepower per pair of gears, but I was in hopes this morning that I would hear something in the nitriding paper that would give us a little hope on surfaces, but I didn't hear anything encouraging in that paper.

J. H. Van Campen: I think the papers which we have just heard cover a very interesting subject. My personal opinion is that each type of drive has its place, and different types of mills require different types of drives.

Some types of mills are designed for three, four, or five speed ranges. They may have it down to two or they may have it down to one; so, in my opinion, there still is a question whether the individual motor driven mill has its place for each stand, particularly on a Roughing Train as applied to Hot Strip Mills.

Take Hot Strip Mills, particularly, for an illustration, there is no question about it that on the finishing end you need a wide speed variation; whereas, on the roughing end it is a question. Take the roughing end of the mills for instance, with say, five or six roll stands, invariably the stands are so placed for the first two or three passes that the slab is not in these two or three stands at one time. Result is that you don't need that speed variation in those stands. In the balance of the stands in the Roughing Train, there is no doubt, the piece would be in two or more at one time. There you need a certain amount of speed variation. This can be taken care of by varying roll diameters. You could put the rolls in the last stands and when the wear is beyond the diameters required, these rolls could be moved forward into the other stands, and in that way, compensate for the speed variation required.

Many times you will find on a mill where the roughing stands are driven by one variable speed motor, that upon checking back, the operation is carried through with that motor set on one speed point continuously, as they find that it is not necessary to have variable speed.

G. P. Wilson: There has been a tendency because of the fact that the synchronous motor has been very highly developed, to apply the synchronous motor and get exactly the same result as if you have a lineshaft to the synchronous motors. It will not drop its speed, so you can simplify your gearing and cut out a lot of the lineshaft by applying synchronous motors to the roughing stands, and this is being advocated on some mills.

F. W. Cramer: I would like to ask Mr. Ellis a question on this bloomer. On the ordinary reversing blooming mill, we have the one large armature and the pinions. On your new design you have eliminated the pinion and you have two small armatures. On your starting, stopping and reversing, does either one have a distinct advantage or do you wind up about the same place?

R. H. Ellis: I think perhaps the electrical manufacturers might answer the question on starting and stopping, but there is another issue involved in a big blooming mill, the motor equipment with 4,000,000 foot pounds of torque on it, requires a very big pinion housing. Eliminating the pinion housing is the important gain in the mechanical end. Whether it has any complications in starting or stopping the two different motors, I think Mr. Wilson can answer.

F. W. Cramer: I meant in time.

R. H. Ellis: I don't think there is any advantage. It ought to be just as good, but I really didn't go into the figures. The electrical company took care of that end of it.

F. W. Cramer: What are your figures? Is there any advantage on starting, stopping or reversing?

G. P. Wilson: The flywheel effect, of course, is smaller with the twin-motor drive than it would be with the individual motor-driven mill, due to the fact that you have your W R square loss on the individual twin-motor drive. There is no starting difficulties, however, in applying the twin-motor drive. The control is fairly simple and very much like the single-motor drive. The idea is somewhat the same as applying double generators to a single armature, single armature reversing wind, so that there is no particular difficulty in starting or matching the speed, as the speed of the two motors are identical.

R. M. Hussey: Referring to the question that Mr. Cramer just asked, I don't believe you got the answer to it. It is my understanding that although the W R square of the combined twin-motor drive is less, as you would expect, the fact that it is less is not a determining factor in the speed of reversal. It is my understanding that the speed of reversal is determined more by field characteristics than it is in the W R square in the revolving element.

L. A. Umansky: Mr. Hussey's question is right to the point. The speed of reversal of a, say, blooming mill motor does not depend so much on the mechanical inertia of its rotating parts, as we are apt to think. In a paper which I was privileged to present before this Association a few years ago, I have pointed out, by means of a typical example, that if it were the problem of mechanical inertia alone, a mill motor could be reversed from full speed ahead to full speed reverse in less than one second; in other words, the speed of reversals would not be a problem at all.

The real problem confronting the electrical manufacturers in this respect is the so-called "magnetic inertia," i.e. the ability of fields of the motor and of the generators to build up quickly and to die down equally fast. Here is where most efforts were concentrated and where most noticeable progress was made.

It is quite fair to state that an up-to-date electric drive, with properly designed control, will reverse as fast, or faster than rolling conditions require it. Thus, the mill tonnage is again made contingent, not on the main roll drive, but on the speed with which the steel is manipulated between the passes.

If the WR^2 of the reversing motor is considered, it should be brought into the picture in an entirely different light. Assume that your motor is good for a maximum operating torque of, say, 2,000,000 lb.-ft. or any other like value. Where is this torque developed? The answer is: in the motor armature itself. If the motor runs at a steady speed, then the full value of this torque is available at the coupling: the terms "motor torque" and "torque at the shaft" then coincide. But, on the other hand, if the motor should take a heavy draft and, at the same time, should be accelerated, (and this is the manner in which all blooming mills are operated), then of the total "motor torque" a portion should be reduced in order to accelerate the armature at the desired rate and only the balance will be left "at the shaft" to do some useful work. Thus, for a given "guaranteed maximum operating torque" the motor with a greater WR^2 will either force the operator to accelerate the mill with the steel in the rolls at a lower rate, or—if the rate of acceleration is to be maintained—will force the operator to reduce the drafts. In either case the mill tonnage might be sacrificed to a certain degree if the motor WR^2 is excessive.

It is on this basis only that the various values of motor WR^2 and of the maximum torques should be jointly compared and analyzed. But the "speed of reversal" is not a measure of the motor WR^2; it is, in reality, the function of control.

And now let us face the problem of single-unit vs. double-unit, or even four-unit reversing motors.

It should be admitted, to begin with, that on an equal basis, the single unit motor is somewhat more efficient than its double-armature counterpart; this can be readily understood by remembering that the relative length of the armature end-connections is reduced, and therefore, the copper losses are also reduced. Say, the full load efficiency is improved from 91% to 92%.

It is questionable in my own mind whether such improvement represents anything tangible, even from the standpoint of power saving. The load on the reversing motor is not steady, but fluctuates rapidly and frequently from zero to maximum. The I^2R losses at high peak loads are what really count, while the losses or efficiency at "rated load" are correctly estimated, but meaningless values.

Now a single unit motor is apt to have a larger WR^2, everything else remaining equal. This means that in order to develop the same useful torque at the coupling while accelerating with load, this motor will draw a heavier current than a double unit machine. Thus in the formula for copper losses (I^2R), in the case of high accelerating peaks, the single unit motor will have a lower value "R", but a higher value "I". This fact should bring the actual operating efficiencies of the motors much closer together than the "full load" or "paper efficiency" would imply.

Under the circumstances I would be inclined to disregard this matter of efficiency, as usually defined, of a reversing motor in comparing the single vs.

double-unit drives. First cost and relative commutating ability should determine the choice.

Now, everything said in respect to the double-unit motor applies to a still greater extent to the 4-unit construction adopted for the South Chicago 54" mill. The cost will go up; space requirements will be undoubtedly very much larger; but if the elimination of the mill pinions and a separate drive for each roll is considered as an advantage, then this scheme has its own legitimate field.

It is, of course, particularly well adapted to such large mills, like the 54" mill in question. But if the mill is only of, say, 40" size, then the vertical distance between the center lines of the two motors becomes more limited and the maximum permissible motor diameter becomes quite small. Now, the motor torque drops off more rapidly than the first power of its diameter. It may become necessary to split each of the two drives into two units, thereby providing say, four 1750 H.P. motors instead of one 7000 H.P. unit. The expense involved may not justify the expected results. Generally speaking, the smaller the mill, the less justification there is to go to type of drive which was quite in order for the Chicago mill.

As to the means of controlling the two or four motors together, this is not a very complicated problem for the electrical engineers to solve. In fact, it has been already solved in a number of instances, quite a few years ago. At your own weldpipe plant, Mr. Hussey, you have two 15 H.P. D.C. motors each driving one roll of a cross-roll mill; nothing but the pipe itself provides a mechanical tie between the two drives; both motors are even reversing. And yet both are running at the same speed, and both divide evenly the total load.

Several tube expanding mills are similarly equipped with two 1500 D.C. motors, one motor per roll.

A still better example is the reversing slabbing mill at Steubenville, where one 7000 H.P. and one 1750 H.P. are driving separately the horizontal and the vertical rolls respectively. Both sets of rolls are free from each other, but work together on the same ingot.

Finally, the wide flange beam mills at Lackawanna and at Homestead have also separate drives for the main and for the supplementary rolls.

The successful operation of all these mills should leave no doubt that from control standpoint there is no trick whatsoever to drive each roll of the reversing mill by a separate motor. This problem, in all its essential parts, has been already solved.

Items of Interest

PERSONNEL CHANGES

W. H. Davey has resigned as president of the Empire Steel Corporation, Mansfield, Ohio and has been succeeded by C. H. Henkel, Mansfield attorney, formerly executive Vice President.

Stanley H. McKee has resigned as Chief Engineer of the Republic Steel Corporation. Mr. McKee started with the Republic Iron and Steel Company twenty-five years ago as a draftsman.

John H. Barker, representing The LaBour Company, Inc., Manufacturers of self priming pump has been moved to the Tribune Building, at 154 Nassau Street, New York, N. Y.

W. M. Kelley, Master Mechanic of Jones and Laughlin Steel Corporation, Aliquippa Works, has resigned to accept a position with the Republic Steel Corporation at Youngstown, Ohio.

E. A. Hurme, District Manager, Clark Controller Company, Pittsburgh, Pa., has just returned to the United States from a business trip through the European Industrial centers.

J. A. Northwood, an active member of the A. I. & S. E. E. Safety Engineering Division, has just recently been appointed the Management's representative of the Sparrows Point Plant of the Bethlehem Steel Company, Sparrows Point, Md.

James S. Fenton has been promoted to the position of sales engineer of the New York Office of the Reliance Electric & Engineering Company, Cleveland, Ohio, manufacturers of alternating and direct current motors.

R. L. Hermann, formerly Transportation Manager of the Southwestern District, Westinghouse Electric and Manufacturing Company, has recently been appointed Heavy Traction representative, with headquarters in New York. With the exception of three years of service in the army, he has been continuously identified with the Westinghouse Company since his graduation from the University of Illinois in 1915.

J. T. Osler, president of the Continental Roll & Steel Foundry Company, has announced the appointment of H. A. Lomax as general manager in charge of the Wheeling Mold & Foundry division of the company. Mr. Lomax formerly was associated with the Duquesne Steel Foundry Company, Pittsburgh.

The Continental company recently was formed through a consolidation of the Wheeling and Duquesne companies and of the Hubbard Steel Foundry Company, East Chicago, Ind.

The Brown Instrument Company announces with regret that Mr. George W. W. Cornman, Treasurer and Manager of the Service Department of The Brown Instrument Company, will retire from business, effective August 8, 1930.

The Service Department will be in charge of Mr. R. C. Kennan as Manager, and Mr. E. T. Nahill as Field Supervisor.

E. J. Best has joined the staff of Freyn Engineering Company and has gone to Leningrad, U.S.S.R., to join the group of Freyn Engineers who are rendering consulting service to Gipromez, the Soviet organization in charge of the projection of new iron and steel plants.

C. E. Hilkert has been appointed manager of the recently created by-products division of the Republic Steel Corporation, it is announced from Youngstown, Mr. Hilkert formerly was with the Central Alloy

Steel Corporation at Massillon. As manager of the by-products division he will have charge of sales of the coke and all coke by-products including benzol and ammonia sulphate, scrap brass, cinder and other mill waste, and second-hand and old machinery. The headquarters of the new division will be in Youngstown.

E. C. Wilson formerly in charge of the pricing group of the Gear and Reducer Division of Foote Bros. Gear and Machine Company, Chicago, has recently been appointed Assistant Sales Manager. Mr. Wilson was until 1929 Assistant Sales Manager of the R. D. Nuttall Company of Pittsburgh, Pa.

Carl G. Ohlson of Youngstown, Ohio, will become associated with Morgan Construction Company, Worcester, Massachusetts, as Assistant to its Vice President, Mr. J. W. Sheperdson, on the first of September next.

Mr. Ohlson has been connected with Youngstown Sheet & Tube Company for fifteen years, during the last five years of which in the capacity of Consulting Engineer.

Twelve steel mill engineers sailed on the Bremen, July 17, on the first lap of their journey to the U.S.S.R. These men comprise the first of several groups of engineers Freyn Engineering Company is sending abroad in connection with its contract to design and build a complete steel plant at Kuznetsk, Siberia.

The people composing this group are: Arthur O. Baer, Franklin Glenn, George W. Campbell, Alexander A. Burrell, Theodore A. Hoffmeyer, Walter M. Lundergan, Joseph E. Brown, A. B. Neumann, Mr. and Mrs. A. S. Hellstrom, Alexander Manus, Oscar Johnson and Mr. and Mrs. A. J. Winetz and daughter.

Part of this group will be located at Moscow and the remainder at Kuznetsk, the site of the new plant. A second group of engineers will sail within a few weeks.

Theodore Dreier, graduate of Harvard, and for the past five years an electrical engineer at the General Electric Company in Schenectady, N. Y., has been appointed Assistant Professor of Physics at Rollins College for the coming year, it is announced. Mr. Dreier will fill a vacancy caused by the death of Dr. William S. Franklin in June.

E. C. Gainsborg, formerly Pittsburgh Representative of the SKF Bearing Company, has recently been appointed Pittsburgh District Manager of the Cleveland Crane & Engineering Company with offices located at the Farmers Bank Building, Pittsburgh, Pa.

WITH THE MANUFACTURERS

The Combustion Engineering Corporation have prepared a new catalog which presents a detailed and well illustrated description of the C-E Fin-Tube Economizer. Copy of the catalog may be obtained by interested parties by writing the above concern at 200 Madison Avenue, New York.

The Swindell-Dressler Corporation composed of the William Swindell and Brothers, American Dressler Tunnel Kilns, Inc., The Gas Combustion Company and the Duquesne Burner Service Company, are distributing a very attractive booklet entitled "80 Years of Progress." The booklet gives the brief history of the individual companies forming the corporation as well as a list of the officers of the new corporation telling their past connection with consolidating companies and their duties with the new corporation. Copy may be obtained by writing Swindell-Dressler Corporation at Pittsburgh, Pa.

A new bulletin just off the press which describes and discusses the de Florez System of Remote Manual Control is being distributed by The Brown Instrument Company of Philadelphia. Copy of this bulletin 7520 may be obtained on request.

The 1930 issue of Catalog No. 80 "Resistance Thermometers" which treats in detail of Leeds and Northrup Resistance Thermometers for recording, controlling and indicating temperatures may be secured by writing the Leeds and Northrup Company at Philadelphia, Pa.

"Color to Lengthen Motor Life" is the title of a new mailing piece prepared by The Reliance Electric and Engineering Company of Cleveland, O. This is a new idea advanced by The Reliance Electric and Engineering Company to obtain steadier operation and longer life from motors. The Reliance orange-colored enamel is used on direct-current motor windings so that maintenance men can detect trouble-making dirt at a glance. Copy of the new mailing piece describing this new idea may be had by writing the above company.

"The Hump Method for Heat Treatment of Steel" is the title of a new 40-page catalog No. 90. This new issue is similar to the last edition except that it contains a presentation of the problem of control of the rate of heating above the critical with the same precision as below it. Copy of this new edition of Catalog No. 90 may be obtained by writing Leeds and Northrup Company at Philadelphia, Pa.

HEAVY DUTY BUCKET

The Erie Steel Construction Company have developed a new Clamshell Bucket for heavy duty service. This bucket will be known as a Heavy Duty Clamshell Bucket and it is similar to the other types of lever arm buckets excepting that it is much more rugged in construction. It is built to stand up under the severest kind of abuse and service which is usually found around steel mills and industrial plants.

It is of all steel construction and has the sheaves at the extreme end of the power arm where they will exert the greatest amount of leverage. The ropes have straight leads without S bends. S bends cut cable life 40 to 50 per cent. The Heavy Duty Bucket can be reeved with 3, 4 or 5 parts of closing line. The number of parts of closing line together with the lever arm makes the bucket a powerful digger as well as speedy in operation.

The head of the bucket is made for great rigidity and strength. It is provided with large bearings and built-in guide rollers. The head plate strengthens the corner bars placing the digging strain evenly on all four corners of the bucket.

The scoops are well banded and the back band ties in with the power arm, thus making three thicknesses of metal at the usual breaking point. The lips extend entirely to the top of the bucket and also tie in with the power arm and hinges. The

lips are furnished of either high carbon or manganese steel as desired. Stellite cutting edges are available on All Erie Buckets.

Heavy steel flanged plates are used to make the scoops strong so that they will stand the repeated striking of iron in cupola refuse pits.

A MACHINE FOR ROLLING HEAVY METAL FORMS

Heretofore machines for forming heavy sheet metal into window framing, cornice molding, door butts and the like, have been of the "brake" type, operating on the principle of a press. Roll machines have been used only for comparatively narrow strips of light metal, as in making furniture hardware and similar articles. The J. S. Thorne Company, of Philadelphia, however, has recently had built by the Dienelt & Eisenhardt Company of the same city, a metal forming machine which will roll 10 gage material up to 36 inches width.

The machine consists of twelve pairs of horizontai rolls, between which the strips of metal pass. These rolls are so shaped that the metal is progressively molded into its final shape, the impressions becoming sharper and deeper as the material passes through the machine, thus permitting sharp angles without breaking at the bends, which might occur if the material were formed too much by a single set of rolls. All operations are mechanical, beginning with the flat material and ending with the finished product, no intermediate rehandling and readjusting being required between the impressions, as would be necessary with a brake machine.

The speed of travel is approximately 65 feet per minute while the machine occupies a floor space of only 22 ft. 6 in. by 8 ft. 4 in., or of 22 ft. 6 in. by 13 ft. 4 in. in a duplex machine of double capacity, so that great economy in time, labor and floor space is realized as compared with former practice.

To prevent wide and heavy material from rising and buckling between the rolls, the forming rolls are set close together, the horizontal center distances being only 16 inches. In handling heavy gage material narrower than 36 inches, it is desirable that the bearings of the rolls be moved inward in order to reduce roll deflection. This is accomplished by making the bearing housings or supports movable upon the base plate and by bushing the rolls so that the bearings can run at any point desired. When the housing of the second pair of rolls has been removed, then the housings of the other rolls may be shifted inward by varying distances. The vertical clearance between the rolls is adjustable by means of hand wheels on the bearing housings, which also are fitted with gauges. Individual rolls are removable.

The rolls are geared together by intermeshing spur gears in four groups of three, each of which is driven from a top drive 17½ ratio worm reduction gear, the worm spindles being coupled together to form a continuous longitudinal line shaft. The motor shaft, which runs at 860 r.p.m. is not directly connected to the line of worm spindles, but drives it through a helical reduction gear of 2.03 ratio.

The worm wheel shaft of each worm gear is extended upon both sides, thus providing for the installation of a duplicate row of rolls on the opposite side of the worm gears; the 175 hp. motor being sufficiently powerful to operate both sets, although ordinarily only one side will be in use while the other side is being set up. In case of very long runs, however, both sides can be used to obtain double output.

NEW THREE POSITION PILOT SWITCH

Motor driven pumps, compressors, and similar machines which are controlled by an automatic pilot device such as a float switch, pressure switch, time clock, etc., often require some means of starting and stopping the motor manually. For this purpose, Cutler-Hammer, Inc., 157 Twelfth street, Milwaukee, Wis., have developed a new three-position pilot switch. The operating lever can be placed in either the "automatic," "off" or "manual" position. When turned to "automatic," the automatic pilot device is in circuit and normal, automatic operation is obtained. With the lever in the "off" position, the pilot circuit is opened and the motor cannot be started from any other control point. Turning the lever to the "manual" position closes the control circuit direct and the motor will run continuously regardless of any other control devices as long as there is operating voltage on the line. The construction is extremely simple. It consists of a two-button pushbutton switch inside the case, the buttons of which are operated by a cam attached to the operating lever. The lever will remain in any one of the three positions.

RECORD-BREAKING TURBINE GENERATORS FOR THE BROOKLYN EDISON COMPANY

Two turbine generators that will set several records for capacity and size are being constructed at the Schenectady works of the General Electric Company for installation in the Hudson Avenue station of the Brooklyn Edison Company. One will be installed in September, 1931, and the other in April, 1932.

Each turbine will be of tandem-compound construction, with double flow in the low-pressure cylinder, and will drive a single generator of 160,000 kilowatts capacity at 0.8 power factor, with a maximum output of 200,000 kilovolt-amperes. The unit is, therefore, the largest single-shaft machine operating at 1800 revolutions per minute. Without auxiliaries or attachments the combined weight of each turbine and generator will be more than a thousand tons. The turbines are designed for steam conditions of 400 pounds gauge pressure, 730 degrees Fahrenheit total temperature, and one-inch absolute back pressure. Provision is made for bleeding steam at two stages for heating the feed water to a temperature of 270° F. The compactness of the unit is shown by the fact that an output of almost 100 kilovolt-amperes is obtained from one square foot of floor area.

The Turbine

The steam is admitted to the turbine through five control valves which open in sequence and therefore result in a very flat load curve and high economy at partial loads. The turbine will operate from half to full load with a change in efficiency of less than two per cent. The steam exhausts from

the high-pressure element into the double-flow low-pressure element through two crossover pipes which have a total cross-sectional area of 46 square feet. The large buckets of the last stage travel with a tip velocity of approximately 13½ miles a minute.

When the turbine is operating at full load it requires approximately 800 tons of steam per hour. This steam is delivered to the turbine through two steam lines 22 inches in diameter. The turbine generator will consume its own weight in steam every 75 minutes.

In each stage of the turbine the nozzle diaphragms first accelerate the steam to approximately 1600 feet a second velocity, and then direct this high-velocity steam into the rapidly moving buckets of the turbine wheels. In this way the heat energy in the steam is converted into mechanical energy, and the steam which enters the turbine at a temperature of 730° F. is exhausted in a small fraction of a second with its temperature reduced to 80° F. Because of this rapid conversion of heat into work, the turbine may be considered as a gigantic refrigerating machine. Thirteen tons of steam are reduced in temperature every minute from 730° F. to 80° F.

The Generator

The generator that will be driven by this turbine is an outstanding engineering achievement for it is the largest single generator in the world. Rated at 160,000 kilowatts, 16,500 volts and 7000 amperes, it operates at 1800 revolutions per minute. As it is an 0.8 power factor machine, the full load output of 200,000 kilovolt-amperes will be considerably greater than the output of the 160,000-kilowatt, 160,000-kilovolt-ampere generator now operating in the East River station of the New York Edison Company. Seventy-one of the new generators, operated continuously for one year, would generate close to 100 billion kilowatt-hours, which quantity slightly exceeds the total electrical output of the United States for all purposes during 1929.

The Hudson Avenue station once contained the largest single-shaft generator, and when the new units are installed it will have still greater distinction for it will then contain two duplicate generators which are the largest single-shaft machines in the world.

Cooling air will be forced through the generators by four motor-driven blowers enclosed in a separate structure on top of the generator stator. All four blowers will force 220,000 cubic feet of air per minute through the generator; at light loads less cooling air is required, and some of the blowers may be shut down. The losses in the generator which appear as heat in the circulating air will be recovered by passing the circulating air through surface air coolers, through which the condensate will be circulated. This condensate will be used as feed water for the boilers. The air coolers are placed above the turbine room floor, two on each side of an integral with the generator. Auxiliary coolers will be installed for use when necessary, employing sea water as a cooling medium.

The steel portion of the revolving field will weigh approximately 185,000 pounds, and about 18 tons of copper strip will be required for the field winding. A special railway car will be required to ship the rotor, which will have a net weight of almost 150 tons.

The stator for the generator is so large and heavy that it exceeds both in dimensions and in weight the shipping limitations of the railroads. The stator frame will therefore be made in halves, and these halves will be joined in the Hudson Avenue station. The core, consisting of more than 150 tons of silicon steel punchings, will then be assembled, after which the armature windings will be installed in the armature core. These windings are not special in any respect except as to dimensions.

The new 160,000-kilowatt turbine generators will represent an outstanding achievement since each single-shaft unit, with its single generator, will occupy in the power station a portion of the turbine room originally intended to accommodate a 50,000-kilowatt equipment, a unit of less than one-third the capacity.

MAGNETIC STARTER

The Electric Controller & Manufacturing Company of Cleveland, Ohio, announces a new Magnetic Starter. This starter, complete with overload relays and a self-contained potential transformer (to secure 220 volts for the control circuit) is intended for across-the-line starting of Squirrel Cage and Synchronous Motors and may also be used to control the primary of Slipring Motors. The starter is built for reversing, non-reversing and plugging applications.

The design of this starter is radically different from the switchboard circuit breaker type of starter commonly used in the past for full voltage starting of high voltage A.C. motors. There are no bell cranks, toggle mechanisms or lever systems between the magnet armature and movable contact arm. The magnet armature, carrying the moveable contact arm, is direct acting and is supported by only one large bearing pin and since the entire unit is totally oil-immersed, all working parts are always well lubricated and protected from dust and corrosion. This insures the equipment is ready for operation at any time, whether it is out of service for a few minutes or for several months.

The contacts used on this, the type ZHS Full Voltage Magnetic Starter, are likewise very different from previous 2300 volt designs. They open and close the circuit with a wiping and rolling action, are duplicate and are easily renewable.

The enclosing case is a heavy welded steel tank, which houses the completely wired unit. A longer tank containing two type ZHS magnetic contactors, mounted back to back and mechanically interlocked, is supplied for reversing, non-reversing and plugging applications. This unit construction provides a flameproof, corrosionproof and dustproof installation that may be mounted anywhere with perfect safety. It is not necessary to build an expensive control room for these starters. Frequently, it will prove very economical to mount them out in the plant alongside the motors they control, thereby permitting a very substantial saving in installation costs. It is perfectly safe to do this, because all live parts are totally enclosed and grounding the case provides a shockproof installation.